University of Bergen

Faculty of Medicine

Master Thesis

Infant growth in the KwaZulu-Natal province, South Africa: Results from the KwaZulu-Natal initiative for breastfeeding support (KIBS) survey II at 13-15 weeks and 6 months of age

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15th of May 2018

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Study Program: Master in Clinical Nutrition

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Operational definitions

KIBS 2a and KIBS 2b: KIBS 2a refers to the 13-15 weeks old infants while KIBS 2b refers to the 6-7 month old infants participating in KIBS II. Note that these are two separate groups of infants, and are only measured at the same point in time.

Malnutrition: According to the World Health Organization (WHO), the term malnutrition encompasses two broad groups of conditions, where undernutrition (wasting, stunting and underweight) and inadequate levels of vitamins or minerals is one, and the other is overweight and obesity and diet-related non-communicable diseases (1, 2). However, recent studies acknowledges the existence of micronutrient deficiency in both over- and undernutrition as well as non-communicable disease in a life course. This thesis uses malnutrition defined by anthropometry only.

Anthropometric definitions

Anthropometry: "Measurements of the variations of the physical dimensions and the gross composition of the human body at different age levels and degrees of nutrition" (3). Anthropometry is used to describe the nutritional status of an individual and is mainly used to either describe body size or body composition (3).

Z-scores: "The z-score system expresses anthropometric values as several standard deviations (SDs) below or above the reference mean or median value. Because the z-score scale is linear, summary statistics such as means, SDs and standard errors can be computed from z-score values. Z-score summary statistics are also helpful for grouping growth data by age and sex. The summary statistics can be compared with the reference which has an expected mean z-score of 0 and a SD of 1.0 for all normalized growth indices" (4). Formula below is retrieved from WHO Global Database on Child Growth and Malnutrition (5).

$$\mathrm{Z-score} = \frac{\text{observed value} - \text{median value of the reference population}}{\text{standard deviaiton value of reference populaiton}}$$

Wasting: Weight-for-length z-scores (WLZ) <-2.

Stunting: Length-for-age z-scores (LAZ) <-2.

Underweight: Weight-for-age z-scores (WAZ) <-2.

Overweight: WLZ >2 in children. Body mass index (BMI) between 25.0 – 29.9 kg/m^2 in adults.

Attained growth: Attained growth is a measure of growth at a single time point and describes how the child has developed in terms of growth up to that time point. Length/height-for-age, weight-for-length/height and weight-for-age are the most common indices for attained growth (6) in children.

Growth velocity: Growth velocity is a measure of longitudinal growth and the velocity can be calculated when several measurements of weight and height/length are made. The outcome measure (velocity Z-score), describes the growth occurred and development between the measurements, this is however dependent on the time in which the change has happened (7).

This thesis will use attained growth standards from the WHO Child Growth Standards (2006) (8) to estimate anthropometric status.

Abbreviations

AFASS	Acceptable, Feasible, Affordable, Sustainable, Safe
BFHI	Baby Friendly Hospital Initiative
BMI	Body Mass Index
C-IMCI	Community Integrated Management of Common Childhood Illness
Cm	Centimetres
EBF	Exclusive Breastfeeding
eMTCT	Elimination of Mother-to-Child Transmission of HIV
EPI	Expanded Programme on Immunization
HAZ	Height-for-age Z-score
HEI	HIV exposed and infected
HEU	HIV-Exposed-Uninfected
HIV	Human Immunodeficiency Virus
HUU	HIV-Unexposed-Uninfected
IYCF	Infant and Young Child Feeding
KIBS	KwaZulu-Natal Initiative for Breastfeeding Support
KG	Kilograms
KZN	KwaZulu-Natal
LAZ	Length-for-age Z-score
LMIC	Low- and middle- income country
NDoH	South African National Department of Health
MGRS	Multicentre Growth Reference Study
MTCT	Mother to child transmission
OR	Odds Ratio
PHC	Primary Health Care

PMTCT	Prevention of mother to child transmission
PPS	Probability Proportional to Size
RHC	Road to Health Card
SADHS	South African Demographic Health Survey
SD	Standard Deviations
SDG	Sustainable Development Goals
UN	United Nations
UNAIDS	Joint United Nations Programme on HIV and AIDS
UNICEF	United Nations Children’s Fund
WAZ	Weight-for-age Z-score
WHO	World Health Organization
WHZ	Weight-for-height Z-score
WLZ	Weight-for-length

Abstract

Background

Today, 155 million children under the age of five years are stunted in the world, 52 million are wasted, while 41 million are overweight. When these conditions exist at the same time, within an individual, household or community, it is referred to as the double burden of malnutrition. Malnutrition is on the world's agenda with several organizations such as UNICEF and WHO working towards a reduction in both over- and undernutrition. Anthropometrical measurements are regarded as the most feasible way of assessing the nutritional status of children. Stunting, wasting, and underweight are measured using length-for-age, weight-for-length, and weight-for-age, respectively.

South Africa has experienced rapid nutrition and lifestyle transition the last 20 years. The prevalence of overweight has gone up among children, with 13% of children under the age of five years being overweight in 2016. At the same time, the stunting prevalence continues to be high, applying to one in three boys and one in four girls under the age of five years. The country is facing both lifestyle related chronic disease and at the same time a high burden of infectious diseases.

This thesis will focus on infant growth and possible factors associated with growth, in the KwaZulu-Natal province, South Africa. The aim is to report the attained growth and nutritional status expressed among children aged 13-15 weeks and 6 months, and furthermore to assess factors associated with growth and risk factors for over- and undernutrition.

Method

The data for this thesis was based on the second cross-sectional survey from the KwaZulu-Natal Initiative for Breastfeeding Support (KIBS), conducted in 2017. The data was so-called end data in the three-year KIBS project undertaken by the KwaZulu-Natal (KZN) Department of Health in partnership with the University of KwaZulu-Natal. The KZN Department of Health aimed to improve infant feeding practices through an intervention divided in three components, with a planned survey at the beginning and at the end of the intervention period. Data was collected in conjunction with routine vaccination by an independent team of data collectors.

Two groups of mother-infant pairs were recruited in two sub-surveys in KIBS II: KIBS 2a (13-15 weeks) and KIBS 2b (6 months). These infants are not related and are analysed in the two separate groups, respectively. Descriptive statistical analysis and risk factor analysis was performed.

Results

The rate of malnutrition is high in KwaZulu-Natal, with 42.9% being stunted and 28.0% being overweight in KIBS 2a. In KIBS 2b these rates were 21.7% and 21.9% respectively.

The risk analysis suggested male sex, low birthweight, mother's positive HIV status and socioeconomic factors as potential risk factors affecting the linear growth of children negatively in both KIBS 2a and 2b. Only birthweight was recognised as a potential factor affecting the rate of overweight among children in KIBS 2b.

Conclusion

The double burden of malnutrition is present in KwaZulu-Natal. The analysis shows how potential factors such as sex, birthweight and HIV affects the possibility of becoming malnourished. Furthermore, through the use of a hierarchical framework, the analysis illustrates how these factors work through different levels to contribute to malnutrition. These risk factors are coherent with other studies in Africa. There is a need for interventions to stop the increase in overweight among children and at the same time decrease the rate of stunting. In addition, there is a need for improved performance of anthropometrical measurements, as this is a prerequisite for identifying and handling children at risk of becoming malnourished.

Acknowledgement

I would like to thank my main supervisor prof. Ingunn Marie S. Engebretsen at the Centre for International Health for her support and supervision on my thesis, and specifically for introducing me to the world of international health. You have followed me from my bachelor thesis, believed in me and encouraged me to pursue a topic that is not part of our main teaching at the University. Your encouraging words and challenging sessions have helped me understand and see many different sides of nutrition, especially in developing countries in the world. You have introduced me to many interesting and clever people and I thank you for this, and hope we can continue working together in the future.

I would also like to thank Christiane Horwood and her team at the Centre for Rural Health in KwaZulu-Natal. Thank you for letting me be part of your team and for letting me use your data and resources when writing this thesis. Your input on the topic and our discussions about it have been truly inspiring. A special thank goes to your team for welcoming us in Durban and showing us around and making us feel so included.

The scientific environment at the University of Bergen and the Master in clinical nutrition has taught me to be critical and to ask questions next to courses at the Centre for International Health has contributed greatly to this. I am grateful for my student environment and support from friends and family.

Introduction

Malnutrition in the global context

Today, 155 million children under the age of five years are stunted in the world, 52 million are wasted, while 41 million are overweight (9). According to analysis by the Global Nutrition Report 2017, "88% of countries for which data is available face a serious burden of either two or three forms of malnutrition (childhood stunting, anaemia in women of reproductive age and/or overweight in adult women)" (10). When both over- and undernutrition exist at the same time within a country it is referred to as the double burden of malnutrition (11). Several possible mechanisms can explain this. Undernutrition in early life may lead to overweight due to inappropriate or rapid weight gain when the nutritional conditions of the child change after being treated for their undernutrition. Another possible mechanisms is mothers being overweight before or after pregnancy, and are hereby affecting the weight outcome of their child (2).

In 2015, the United Nations (UN) presented the Sustainable Development Goals (SDG), and several of these 17 goals are related to nutrition. The Global Nutrition Report (2017) recognises five collective aims, based on the 17 SDGs, explaining how nutrition has an impact on the 17 goals, and on how systems and programmes in society has an influence on nutrition. These are: 1) sustainable food production; 2) Strong systems for infrastructure; 3) health systems; 4) equity and inclusion; and 5) peace and stability (10). For example, SDG goals 2 (Zero Hunger), 13 (Climate Action), 14 (Life below water) and 15 (Life on land) can be achieved if people can "change what we eat, and how and where we get our food", according to the Global Nutrition Report (10).

There is, however, a discussion on whether the 2nd goal, specifically target 2.2 "to end all form of malnutrition by 2030" is too ambitious with regards to today's prevalence of malnutrition. In a recent study about mapping child growth failure in Africa between 2000 and 2015, the authors discuss how target 2.2 is "clinically vague and almost unachievable" given the complex nature of malnutrition (12). The review also found geographical heterogeneity when it came to improving the rates of both stunting and wasting, which means that some areas in an African country had improved their rates significantly, while other areas in the same country had not improved at all (12).

Defining malnutrition

Measurements of child growth

Worldwide, one in three people is affected by malnutrition (13). The term malnutrition encompasses undernutrition (wasting, stunting and underweight), inadequate vitamins or minerals, overweight and obesity according to the World Health Organization (WHO) (1).

There are two main ways of assessing child growth and thereby malnutrition, these are attained growth and growth velocity. Attained growth is a measure of growth at a single time point and describes how the child has developed in terms of growth up to a certain time point. This value is then compared to either a standard or a reference population. The common standard population used today is from the Multicentre Growth Reference Study (MGRS) (6, 7). In contrast, a reference population is limited to growth in a certain population, in a specific geographical area under investigation. References are made for specific ages and stratified by sex (7).

The WHO Multicentre Growth Reference Study (MGRS) was used in this thesis as the standard population as there is no reference population available for comparison in South Africa. The MGRS was conducted between 1997 and 2003 in six different countries in the world and included growth data of children with different backgrounds. The MGRS is used as the growth standard worldwide and WHO calls it the "Child Growth Standards" indicating that it describes how children should grow under optimal conditions. The requirements for mothers and children to participate in the study represent the optimal conditions. These were: 1) No health, environmental or economic constraints on growth; 2) Mother willing to follow feeding recommendations; 3) Term birth: gestational age ≥ 37 completed weeks (259 days) and < 42 completed weeks (294 days); 4) Single birth; 5) Absence of significant morbidity; and 6) Non-smoking mother (before and after delivery) (14). The purpose was to develop new growth curves for children from birth to five years of age, which would provide an international standard for all (15).

Growth velocity is a measure of longitudinal growth and the velocity can be calculated when several measurements of weight and height/length are made within a certain time period. The outcome measure, called the velocity z-score, describes the growth and development that has happened between the measurements, but is dependent on the time over which the change has occurred (7). Growth velocity is a more sensitive measure of growth change and can demonstrate seasonal variations and the effects of infections better than attained growth. Furthermore, growth velocity has the ability to show significant differences in smaller samples than attained growth.

Attained growth is more convenient for screening and cross-sectional population based studies than growth velocity, mostly because of the need for several measurements for calculating growth velocity but also because there are fewer references against which to measure growth velocity. Currently there is an international standard for growth velocity published in 2009 by the WHO (16), but there is no common cut-off for defining malnutrition as there is for the attained growth standard. The cut-offs for attained growth are based on z-scores and are usually classified as moderate if the z-score is <-2 and severe when the z-score is <-3. Length/height-for-age (indicating stunting), weight-for-length/height (indicating wasting) and weight-for-age (indicating underweight) are the most common indices for attained growth. For this thesis, attained growth will be used, as there is limited data available on length and weight measurements in time.

There are different ways to assess the nutritional state of a child, including biochemical analysis, dietary intake assessment and anthropometric measurements (8). This is most often done with the aim of detecting children who are at risk of malnutrition, or to monitor children's growth on group level and hereby assess trends, or to screen for undernutrition within paediatric care (17). Anthropometrical measurements are regarded as the most feasible as these are non-invasive and relatively easy and cheap to obtain, especially in developing countries where availability of other equipment might be limited. When performed in a standardised manner, anthropometrical measurements are also comparable across sites and at measurement points. The most common anthropometric measurements include length (recumbent) or height (standing), weight, circumferences (head and arm) and skinfold-thickness (triceps, sub-scapular, supra-iliac) (3).

There are various methods for comparing anthropometric indices. Exact age and sex length/height for age, weight-for-age and weight-for-length can be recorded and presented against a reference population. The most common presentation is either in z-scores (standard deviations) or in percentiles. Percentiles are mostly used in clinical setting and refers to: "the position of the measurement value in relation to all the measurements for the reference population, ranked in order of magnitude"(3). Z-scores however, are mostly used in newer research because it allows for more accurate calculations of anthropometric indices beyond the reference population when compared to the use of percentiles. The z-score value "is a measure of the deviation of the anthropometric measurement in terms of standard deviation from the reference populations mean or median" (3). Having either a z-score value of -2SD from the mean or a reference limit of 3rd percentile refers to the same degrees of malnutrition (3). Using the z-score system allows for a continuous description in both negative and positive direction and calculation with that continuous scale. In contrast, the percentile system ranging from 0-100 face limitation on levels towards 'nil' and on levels towards "100", and the scale is thus less flexible for calculations and comparisons across groups of children and within different measurements with extreme values.

Anthropometry

In anthropometric terms, wasting refers to having a weight-for-length/height Z-score (WLZ/WHZ) less than -2 standard deviations (SD) from the current growth standard. Stunting is defined as having a length/height-for-age Z-score (LAZ/HAZ) less than -2 SD, while underweight is defined as having a weight-for-age Z-score (WAZ) less than -2 SD (18). A child is defined as being overweight if their weight-for-height Z-score is more than 2 SD above the median of the reference population.

Stunting describes a state where the skeletal growth is slowing, and can be the result of several events in the past such as insufficient food intake, multiple infections or poor overall economic conditions (7). Stunting is often regarded as a result of long-term undernutrition (chronic malnutrition), while wasting is the result of a recent rapid weight loss or failure to gain weight (acute malnutrition). Moreover, wasting refers to a deficit in tissue and fat mass and it is likely to be easier for a wasted child to restore and gain weight compared to a stunted child growing in length. However, the terms acute and chronic malnutrition might be misleading as wasting may last for several months and stunting can begin as a response to an acute stress situation (19).

Moreover, children with wasting may be or later become stunted as well, indicating that wasting may lead to stunting. The link is not clear, but research suggest that loss of muscle mass and low fat stores can be found in both wasted and stunted children (19). The term underweight describes both wasted and stunted children as it cannot distinguish those from being tall and thin and those who are short but heavy (18). Figure 1 shows the different states of malnutrition with cut-off below minus two and illustrates how a stunted child (a) and a wasted child (b) looks like compared to an average child (20). Length measurements are therefore just as important as weight measurements for classifying undernutrition.

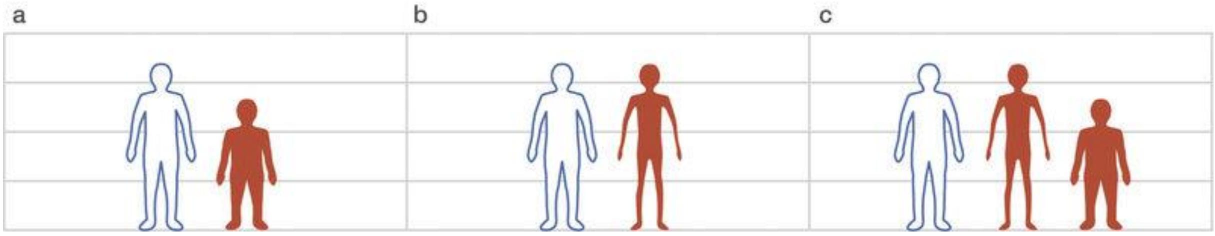

Figure 1. Measurement of child growth failure, comparison of a normal child to a stunted (a), wasted (b) and both (c) at the same age. Adopted from Osgood-Zimmerman et al. (12)

Determinants of malnutrition

The United Nations Children's Fund (UNICEF) Conceptual Framework on malnutrition from 1990, displayed in Figure 2, is a common framework to summarize the main determinants of malnutrition. These are the so-called immediate, underlying and basic causes of malnutrition (21). As an example, inadequate diet and disease burden contribute most to malnutrition among the immediate causes, while food security (access to food) and caregiving, but also access to safe drinking water and hygiene, contribute to malnutrition through the underlying and basic causes (21). In 2013, an adapted framework was published in the Lancet series, illustrated in Figure 3. This version takes the lifecycle approach into account and adds suggestions on possible interventions which may be undertaken while fighting malnutrition (22). Both versions of the framework are displayed below.

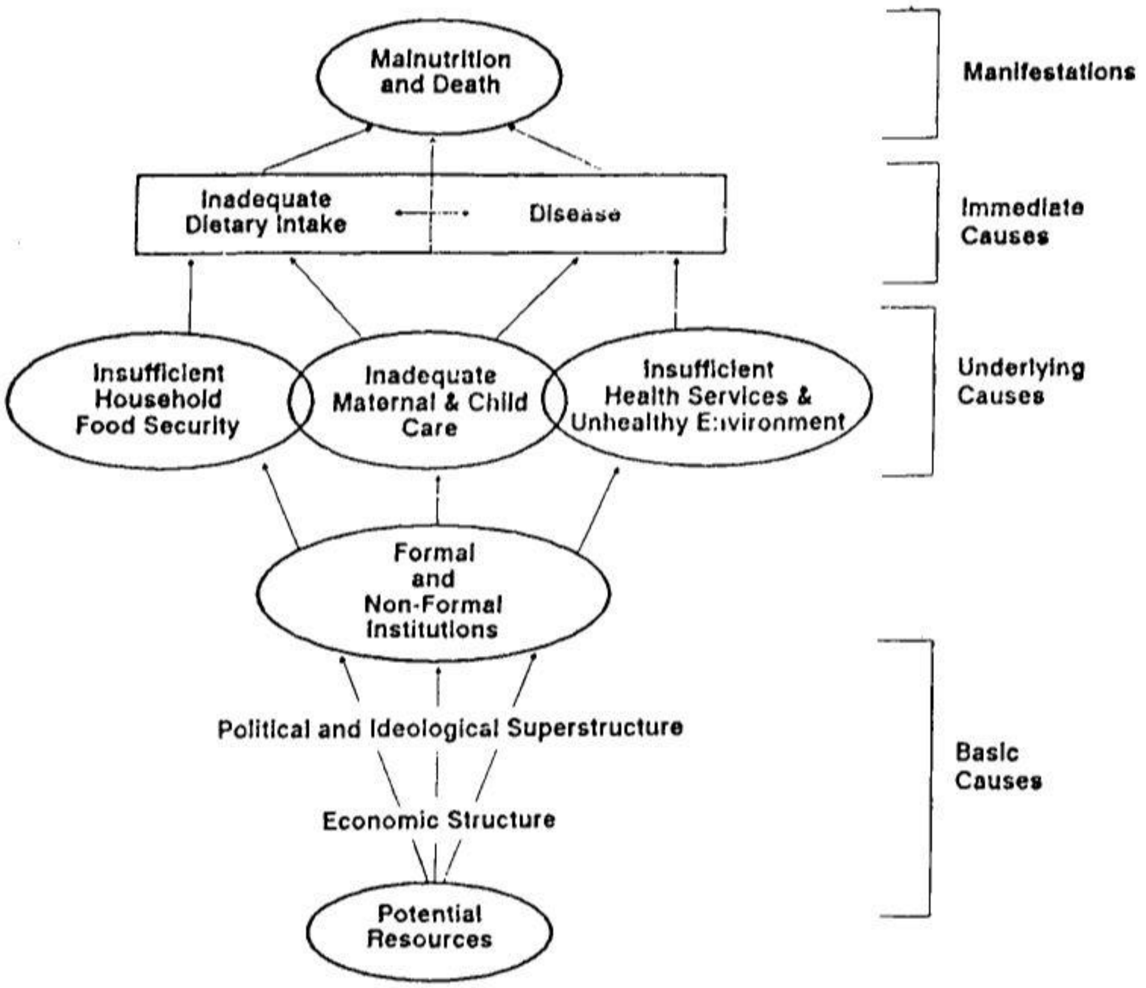

Figure 2. Causes of malnutrition and death. The original UNICEF Conceptual Framework of Young Child Nutrition. Reproduced from UNICEF policy paper (21) with permission from Springer Nature.

Consequences of malnutrition

In the first two years of a child's life, during intra-uterine life and infancy, most of development is completed (23). Children are at risk for poor growth, health and development if exposed to chronic undernutrition during their first 1000 days according to the review by Grantham-McGregor et al. (24). It is therefore important to ensure that children have adequate nutrition during this period so they can learn and grow to their full potential (25, 26). With this in mind, one can understand why the potential long-term consequences of malnutrition are serious.

According to the review article on stunting in developing countries by Prendergast et al. (27), malnourished children are more prone to infections such as pneumonia and diarrhoea which increases their morbidity and mortality. This is partly because their immune system is suppressed when undernourished and the body has to make sacrifices and priorities on what body parts to maintain when there is insufficient energy to sustain all parts. Furthermore, infections can lead to reduced uptake of available nutrients, and thereby worsen the degree of malnutrition (28).

When receiving rapid and adequate treatment, wasted children are considered to have a greater chance of recovering compared to stunted children because stunted growth affects both physical and cognitive development in a greater sense than wasting (29). However, some children might be both stunted and wasted at the same time, making the situation more difficult to treat.

About 20% of child deaths are still due to malnutrition in the world (2). On the other end of the scale, being overweight or obese at a young age may have “both mental and physical health implications and overweight and obesity are major risk factors for cardiovascular disease, diabetes and premature death in adults”, according to WHO (2).

The overweight and obesity rate is increasing in South Africa. The review article on childhood obesity in developing countries by Gupta et al. (30) highlights the following key determinants: reduced physical activity, increased caloric intake, higher socio-economic status, urbanization and residence in metropolitan cities. They also looked at the health consequences for these overweight or obese children and found in example the metabolic syndrome, diabetes type 2, stress, depression and poor learning. This review clearly showed the challenges a child faces if it becomes obese at an early age, and prevention of overweight and obesity is therefore a key nutrition sensitive intervention.

In many parts of the world, food security and diversity is largely dependent on the agriculture in the area. Climate change with longer periods of rain or drought, make agriculture difficult. The seed and agricultural equipment prices often limit poor families from growing desired crops with micronutrient diversity. This, combined with high food prices and marketing regulations may cause challenges for caregivers to provide enough, various and quality food to their children (31).Thus, there are needs to include other sectors than only the health sector to prevent over- and undernutrition in children.

Nutrition sensitive and specific interventions

The Lancet series on maternal and child nutrition from 2013 divides the main intervention types for tackling malnutrition in two, these are nutrition specific and nutrition sensitive interventions, illustrated in Figure 3. "Nutrition-specific interventions and programmes address the immediate determinants of fetal and child nutrition and development – adequate food and nutrition intake, feeding, caregiving and parenting practices, and low burden of infectious disease" (32). Nutrition specific interventions include promotion of optimum breastfeeding, and complementary feeding practices. "Nutrition sensitive intervention address the underlying determinants of fetal and child nutrition and development – food security; adequate caregiving resources at the maternal, household and community levels; access to health services and a safe and hygienic environment – and incorporate specific nutrition goals and actions" (32). Early child development and maternal health programs could be examples of nutrition sensitive interventions. In short, nutrition sensitive programmes include interventions which are "further away from the mouth", while nutrition specific interventions are "closer to the mouth". As the framework shows, there is a need for knowledge about the current situation concerning infants feeding habits and growth in an area.

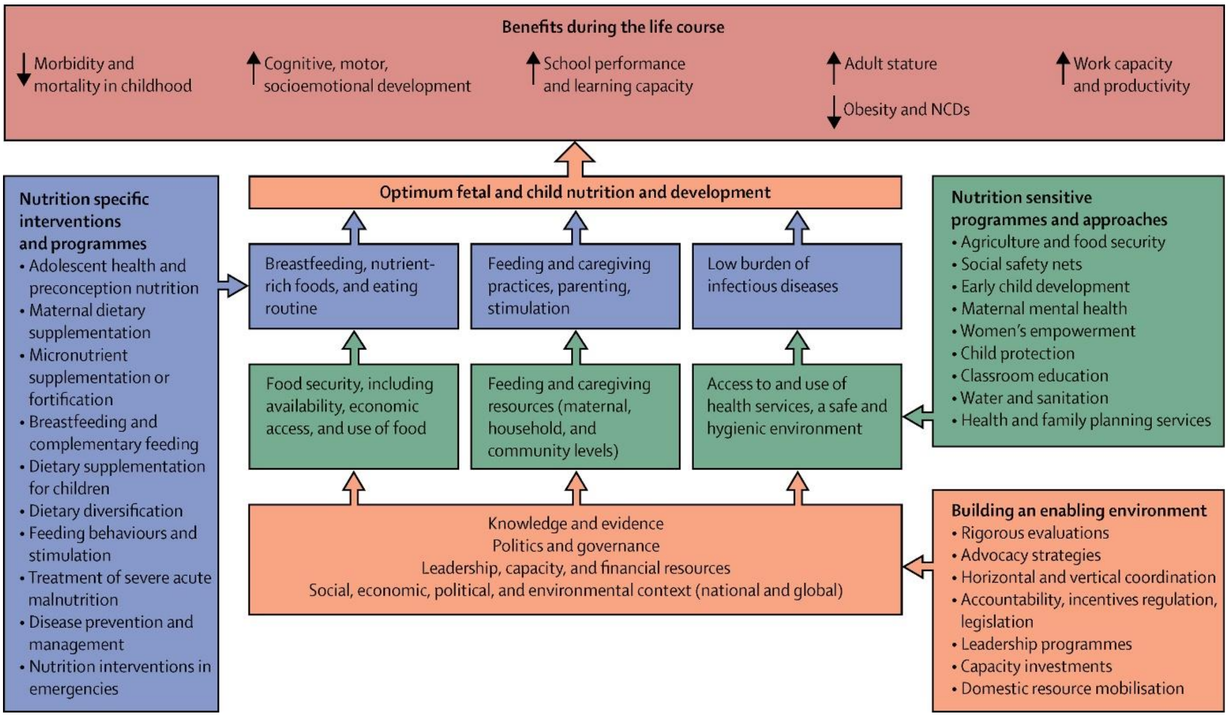

Figure 3. Conceptual framework for causes of child malnutrition, reproduced from Black et al (22) with permission from Elsevier

Nutrition transition

Today, two billion adults in the world are overweight, meaning that they have a body mass index (BMI) of more than 25 kg/m^2. This is more than 40% of all the adults in the world (10). Being overweight or obese is a reflection of energy imbalance where more energy is stored than is used by the body.

Diets are changing in low- and middle-income countries (LMIC) to the so-called "Western diet" in both urban and rural areas. This process can be referred to as the nutrition transition. The western diet is characterized by high intakes of refined carbohydrates, added sugars, fats, and animal-source foods. This is combined with higher availability and more accessible food than earlier. By adopting this diet, people are moving away from more traditional diets rich in legumes, vegetables and coarse grains (33). The nutrition transition is also associated with lower energy expenditure and less physical activity, thereby leading to a larger proportion of people becoming overweight and obese.

The nutrition transition is often the result of a country in fast economic and demographic development which takes on the western diet thus pulling the population away from the traditional diet of the culture (34). Studies from African countries suggest that urbanization and economic growth have been the most important determinants for the increase in overweight (35). This is also true for South Africa, which in the last two decades has experienced an increased prevalence of overweight and non-communicable disease next to a growing economy the last 20 years (36). While examining different stages in the nutrition transition in sub-Saharan Africa, Abrahams et al. (34) found the South African patterns of transition differ as they continue to have high prevalences of stunting next to increasing rates of overweight. Recent prevalence data on stunting show that 27% of children below two years are stunted, while more than 50% of women between 15 and 49 years are either overweight or obese (37).

According to the World Health Organization (WHO), the double burden of malnutrition can be within individuals or/and households or/and populations (38). Persisting levels of undernutrition, particularly stunting, and at the same time substantial levels of overweight and obesity has been documented in the same rural community in South Africa (39). Moreover, high levels of central obesity amongst adolescent girls, which is a risk factor for the metabolic syndrome was also found in this area.

When reviewing the association between maternal and child undernutrition in LMIC countries, Victora et al. (40) found that children who were undernourished at an early age, followed by a rapid weight gain, were more prone to central obesity at a later age.

There is a general expectation that stunting rates or the rate of malnutrition will become better when the economy improves in a country. According to Ruel et al. (32) the predicted decrease in malnutrition has been less than expected in South Africa. Moreover, in a recent study, Vollmer et al. (41) found no or a very weak association between increase in macroeconomics and decrease in early childhood stunting, underweight and wasting. They pointed out three possible explanation for this: 1) unequal distribution of income growth between the poor and the richer; 2) income not spent in ways that enhance the nutritional status of children; and 3) no improvement in public services, which are important for improving the nutritional status of a population.

Infant feeding

Exclusive breastfeeding has shown to be an important factor in preventing malnutrition among infants and young children by being a good source of energy and vitamins. Exclusively breastfeed infants for six months have decreased risk of diseases such as gastrointestinal infections, pneumonia and hospitalization compared to non-exclusively breastfed or replacement fed infants (42-44). Stunted, wasted and underweight children have an increased risk of death from diarrhoea, pneumonia and other infectious diseases (22). Increased mortality from diarrheal disease and respiratory infections due to the use of formula milk has also been described, especially associated with suboptimal preparation and hygiene. Further, the children will lack the immune protective components of breastmilk (45) in addition to the breastmilk giving active stimulation of the infant's immune response (46, 47). Recent estimates suggest that by scaling up exclusive breastfeeding and breastfeeding support, 823 000 global child deaths could be prevented every year (48).

WHO and UNICEF recommend initiating breastfeeding within the first hour of birth and exclusive breastfeeding until six months of age. This should be combined with introduction of safe and nutritionally adequate complementary food around six months of age and continued breastfeeding until two years and beyond (46). Early initiation of breastfeeding within one hour after birth has been shown to be important in order to continue breastfeeding the first six months.

After breastfeeding, it is advised by the WHO that the infant should consume semi-solid foods such as mashed carrots, porridges or yoghurts. Children should receive complementary feeding from the moment breastmilk or a breastmilk-substitute alone no longer is sufficient to meet the nutritional needs of the child (49). Introduction of liquids and foods before six months has not shown to improve growth, but rather carries an increased risk of microbiological infections due to unsafe drinking water and low hygiene, next to inadequate nutrient intake (50). This is referred to as mixed feeding (51).

In recent years, there have been various attempt globally to improve infant and young child feeding practices: The International Code of Marketing of Breastmilk Substitutes (The Code), the baby friendly hospital initiative (BFHI) launched by the WHO and UNICEF in 1991, and the Global Strategy for Infant and Young Child Feeding (IYCF) are some of these (44). The IYCF was inspired by the BFHI success with more than 152 countries promoting breastfeeding through "Ten-steps to successful breastfeeding" (52).

The IYCF strategy was launched in 2003 and implements BFHI, and provides education and counselling to mothers with the aim of improving the nutritional status, growth and development of infants through optimal feeding (53). In April 2018, an updated version of the "Ten Steps to Successful Breastfeeding" was issued by the WHO and UNICEF emphasizing the benefits of breastfeeding and giving guidance on practical steps countries can take to protect, promote and support breastfeeding locally (54).

Despite the attempts above, the prevalence of breastfeeding in the world is low, with only 37% of children being exclusively breastfed the first six months of life (48). The 2016 South African Demographic Health Survey (SADHS) found that only 32% of infants less than six months of age are exclusively breastfed (37). However, this is an improvement from 2003 where only eight percent of infants up to six months were exclusively breastfed (55).

Factors for improving breastfeeding rates

Determinants of breastfeeding are multifactorial and operate at social, structural and individual levels. Age of the mother, support from family members and counselling from health workers in the community are some of the factors influencing a mothers choice to breastfeed or not (56). Prelacteal feeding, labour duration, caesarean delivery and maternal overweight are factors which may compromise breastfeeding and the establishment of exclusive breastfeeding (57). The Human Immunodeficiency Virus (HIV) epidemic hampered a lot of prior global initiatives for breastfeeding support as there was a long period of uncertainty on optimal infant feeding for HIV infected women. Confusing and contradictory feeding recommendations for women with HIV may be part of the reason for the low breastfeeding rate in South Africa (37).

In a sub group analysis of a community-based cluster-randomized trial (PROMISE EBF) promoting exclusive breastfeeding in three South African sites in 2012, Doherty et al. (58) described factors associated with early cessation of breastfeeding in South Africa. The majority of women included in the study were HIV-negative and revealed early introduction of other fluids than breastmilk to their infants. Not having decided to breastfeed before having the baby was the strongest predictor of breastfeeding cessation by 12 weeks. In the meta-analysis by Rollins et al. (56) about breastfeeding practices and determinants, they found several other determinants of breastfeeding such as: breastfeeding practices and attitudes within the family, or individual factors such as having to go back to work due to a short maternity leave.

Human Immunodeficiency Virus (HIV) and infant feeding practices

In 2016, an estimated 7.1 million people were living with HIV in South Africa, which is 19% of people living with HIV globally. Among these 7.1 million HIV infected people in South Africa, 56% were on antiretroviral therapy (ART) (59). ART refers to the use of three or more antiretroviral (ARV) drugs when treating for HIV (60).

Mother to child transmission (MTCT) can happen in-utero, during labour and delivery, or through breastfeeding (61). The Elimination of MTCT (eMTCT), previously the Prevention of mother-to-child transmission of HIV (PMTCT) programme, provides drugs, counselling and psychological support to prevent HIV exposed children are getting infected (62, 63). The PMTCT programme was implemented in most sub-Saharan countries between 2001 and 2009 (64).

Previously, WHO guidelines have referred to "options A, B and B+" when suggesting different approaches to prevent MTCT that could be adopted in different countries depending on funding, HIV prevalence and the strength of the health system. However, in 2013 the WHO recommended one of the two approaches on the use of ARV: "1) providing ART during pregnancy and breastfeeding to women who are otherwise eligible for ART (option B); or 2) providing lifelong ART to all pregnant and breastfeeding women living with HIV regardless of CD4 count or clinical stage (option B+)" (60).

With optimal interventions to prevent HIV transmission, transmission rates can be very low. The Kabeho study from Rwanda found HIV transmission rate to be as low as 2,2% at 24 months among breastfed infants who's mothers were on lifelong antiretroviral treatment (Option B+) (65). However, according to numbers by UNAIDS (Joint United Nations Programme on HIV and AIDS), only around 76% of pregnant women living with HIV had access to antiretroviral medicines in 2016 to prevent mother to child transmission (66). A recent study about eMTCT in the KwaZulu-Natal province showed challenges in the health system and operationalisation at public level as reasons for why MTCT still was happening in KZN (67).

During recent years, as more intervention for eMTCT have become available, WHO have published several guidelines on HIV and infant feeding. However, the policies have been inconsistent and, at times, contradictory leading to confusion among health workers (64). After HIV was detected in breastmilk in 1985, the key feeding recommendations for HIV infected mothers in a revised guideline of 1998/2001 was replacement feeding and to avoid breastfeeding. However, this was only recommended when it was Acceptable, Feasible, Affordable, Sustainable and Safe (AFASS). Otherwise, exclusive breastfeeding for the first six months was recommended (68).

Between 2001 and 2012, the South African National Department of Health (NDoH) provided free formula milk in public health facilities. The emphasis was on HIV transmission due to mixed feeding and by distributing free formula milk, mothers were encouraged to not practice mixed feeding. Free formula distribution was provided because most women were unable to afford the formula otherwise (69).

The AFASS criteria were difficult to follow and many mothers ended up practicing mixed-feeding in the years after the introduction of the recommendations (69). It was discovered as the feeding modality carrying the highest risk of HIV acquisition (70). In 2010, South Africa adopted the promotion of breastfeeding as a National Infant feeding strategy, and the distribution of free formula milk ended (71). In later years, there has been a discussion of the potential "spill-over" effect of the use of formula milk instead of breastfeeding the child exclusively, which might also have been due to confusing recommendation on what to practice (72, 73). The distribution of free formula milk, confusion about the guidelines and concern about HIV transmission in South Africa might have had a negative effect on the breastfeeding rates in the country. As mentioned, the exclusive breastfeeding rates in South Africa was 8% in 2003, and 32% in 2016 (47, 11), so a substantial effort in favour of breastfeeding has been done after the new National Infant feeding strategy in 2010.

In 2010, the updated guidelines for HIV infected mothers recommended exclusive breastfeeding for the first six months of life and that should continue up to 12 months or until safe replacement foods can be established with introduction of complementary feeds from six months (74). Antiretroviral (ARV) drugs to prevent postnatal transmission to all pregnant women during pregnancy and lactation (program B) or lifelong (program B+) were part of the recommendations.

The latest version of the HIV and infant feeding guidelines were published in 2016. Mothers are now strongly recommended to “breastfeed for at least 12 months and may continue breastfeeding for up to 24 months or longer while being fully supported for ART adherence”(60). When on treatment, the risk of HIV transmission through breastfeeding is substantially reduced (60).

As coverage of drugs has increased, there has also been an increase in the number of children who are exposed to HIV but not infected, the so-called HEU (HIV-Exposed-Uninfected) children. A recent study in Botswana by Chalashika et al. (75) showed that HEU children were more likely to be underweight, stunted and wasted compared to HIV-Unexposed-Uninfected (HUU) children during their first 1000 days. Furthermore, they found higher prevalence of breastfeeding among HUU children than HEU children, and proposed that this was part of the reason for poor growth of the HEU children, as other studies have showed that sub-optimal breastfeeding or none at all contributes to poor growth (76). Ramokolo et al. (77) demonstrated in a recent analytical cross-sectional survey from South Africa that HEU children had poorer birth and early postnatal growth outcomes than HUU children. Also, mothers with unmanaged HIV infection had a greater chance of having a preterm birth compared to women on ART. However, there are still controversies regarding child growth differences in HEU and HUU children. The child’s HIV status is not the main focus in this study, but we acknowledge that those who are HIV exposed and infected (HEI) have more harmful exposure both in terms of immunological and pharmacological exposure than HEU and HUU children.

Malnutrition in South Africa

South Africa has experienced rapid nutrition and lifestyle transition over the last 20 years. The prevalence of overweight and obesity rates has increased, with 13% of children under five years being overweight in 2016. At the same time, the stunting prevalence continues to be high with one in three boys and one in four girls under five years being too short for their age (37). The country is facing both lifestyle related chronic disease and at the same time a high burden of infectious diseases (36).

In recent years, there have been attempts to improve the malnutrition rates in South Africa. Since 2012, the Framework for Accelerating Community-based Maternal, Neonatal, Child and Women's Health and Nutrition Interventions has been implemented in South Africa. The main goal has been "to improve the health and nutrition status of mothers, new-borns, children and women through community based interventions" (78). The program build on the already existing Community Integrated Management of Common Childhood Illness (C-IMCI), so that it could be most effective. The role of the community health worker would be: health promotion, nutrition counselling and support in the household including infant and young child feeding (IYCF) (78).

It is common to begin childbearing early in South Africa. In 2016, 16% of women aged 15-19 years had begun childbearing in South Africa, and in KZN this was 19% (37). Young mothers are more likely to be dependent on family, especially if they want to continue their education. Furthermore, they might be more receptive of advices and influenced by others due to their lack of autonomy and experience in how to raise a child and teenage pregnancy may be associated with poor outcomes for the baby. Girls below 18 years of age are therefore included in the KIBS II survey to get a representative result of growth of their children and their feeding behaviour.

Rationale

Malnutrition is persisting in South Africa, despite a slight decrease in stunting among children under the age of five years from 32% in 2010 to 27% in 2016. At the same time, 13% of children under the age of five years are overweight and the numbers are increasing. The availability of national data on nutritional status of children has been scarce during recent years, and the SADHS suggests investigation into the causes of malnutrition, especially on infant feeding practices. It is important to address the malnutrition problem in a country where the economic growth is a fact, but where it has not reached out to every part of the communities yet. Further, there are multiple risk factors in the society including food transition, and change in feeding and HIV recommendations. There is a need for increased investment in public health services in order to improve the nutritional status of the population.

This thesis will focus on attained growth among infants under the age of six months and will give an estimation of the current situation in terms of growth in KwaZulu-Natal, South Africa. Furthermore, associated risk factors of anthropometric malnutrition reaching high proportion in the community will be considered. It will also provide estimates on breastfeeding and infant feeding practices in the region. Thus, this analysis will contribute with relevant information in designing more targeted interventions in KZN. The analysis will be based on the KIBS study part II, where measurements from the Road To Health Cards (equivalent to child health cards) will be the basis for calculating WHZ, LAZ and WAZ of infants under the age of six months.

General objective

To report on attained growth and nutritional status expressed as WAZ, LAZ (linear growth) and WLZ (ponderal growth) among 13-15 weeks and 6 months old infants participating in the KIBS II survey in KwaZulu-Natal, South Africa.

Primary objective

To estimate the proportion of malnutrition in infants aged 13-15 weeks and 6 months with a z-score <-2 WAZ, LAZ and WLZ and >2 for WLZ.

Secondary objective

Assess factors associated with growth and risk factors for over- and undernutrition (WAZ, LAZ, WLZ) based on the UNICEF hierarchal framework presented in Figure 7 (21).

Method

Study site: KwaZulu-Natal, South Africa

The KIBS study was conducted in KwaZulu-Natal province, South Africa showed in Figure 4 (79), situated in the southeast of the country. Durban is the largest city, while Pietermaritzburg is the capital (80). In 2016, there were 10.3 million people living in KZN of the total 56.9 million in South Africa (81, 82). The main language in KZN is Zulu, next to English.

Figure 4. Map of South Africa, Kwa-Zulu Natal is indicated by the black arrow

Ethical approval

The KIBS II study was approved by the Biomedical Research Ethics Administration, Durban, KwaZulu-Natal, South Africa (Reference number BE064/14). The Norwegian Regional Ethical Committee was contacted 4th of January 2018 and confirmed that secondary analysis of anonymised transferred data did not require additional ethical approval. All participants provided written informed consent.

Study design

KwaZulu-Natal Initiative for Breastfeeding Support (KIBS)

The data is derived from the KwaZulu-Natal Initiative for Breastfeeding Support Study round two (KIBS II). KIBS II was a second cross sectional survey conducted between Jan and May 2017. The first cross sectional survey (KIBS I) was conducted between May 2014 and March 2015. Results from KIBS I can be found elsewhere (83). KIBS was a three-year project undertaken by the KZN Department of Health in partnership with the University of KwaZulu-Natal. The KZN Department of Health aimed to improve infant feeding practices through an intervention divided in three components, with a planned survey at the beginning and at the end of the intervention period. The first component was training and mentoring of different cadres of health workers to support breastfeeding. The health workers who received training were: nutritional advisors providing nutrition support in primary health care (PHC) clinics; lactation advisors providing breastfeeding support in hospital; and community caregivers who work in the community. These different cadres of health workers had different aims, for example the lactation advisor would support early initiation of breastfeeding in hospitals and provide advice about exclusive breastfeeding (EBF) and safe formula feeding following discharge, the community health workers would provide support for breastfeeding in the household context and nutritional advisors would provide antenatal and postnatal feeding advice. The aim of KIBS project was to improve early initiation and reducing early malnutrition rates (< 6 months).

The second component of the KIBS project was the establishment of Human Milk Banks in one facility in each of the 11 districts in KZN. Standard procedures and training was given to the people working in the clinics. Finally, the third component was a media campaign designed to support key community messages related to the establishment of Human Milk Banks.

Data collection and inclusion criteria

The KIBS study was conducted in all 11 districts in KwaZulu-Natal province, in 30 primary PHC clinics, both fixed and mobile clinics were included. All care-givers (both mothers and other caregivers) aged 15 years or older who attended the clinics for vaccination with children between 13-15 weeks and 6-7 months of age were approached to participate. Women aged 15-< 18 years were included specifically because research (84) has previously showed that these women have different breastfeeding practices and it is important that this population group is represented, especially since there are many young mothers in South Africa.

Participants were interviewed by trained local personnel in isiZulu (local language) or English, using a pre-tested, structured, standardised questionnaire with structured questions. The questionnaire assessed mothers and fathers information, socioeconomic status through household information, infant feeding through breastfeeding and formula feeding, breastfeeding behaviour, knowledge and attitudes. Both mothers and non-maternal caregivers were asked about the feeding of the child, but mothers were asked more detailed questions as they were likely to give more information than non-maternal caregivers about this. Furthermore, questions about breastfeeding behaviour, knowledge and attitudes were only asked to mothers. At the end of the interview, personnel looked into the Road to Health (RHC) card, which is the child health card or vaccination and growth monitoring card used in South Africa. This was done to note the anthropometric measurements performed until the day of the interview and to assess how the child was growing. The length and weight measurements noted were the basis for analysis and calculations in this thesis.

Randomisation and sample size calculation

Multistage stratified random sampling was used to select health facilities in each of the 11 district in KZN province. Thirty clinics were randomly selected using probability proportional to size (PPS) calculations from a list of all 536 PHC facilities (both fixed and mobile clinics) in KZN. Clinics were selected irrespective of the district size as the aim of KIBS II was to provide provincial level estimates of feeding practices. Thirty interviews were conducted in each clinic and data collection continued until the required number of interviews was completed.

Data management

Data was collected using a tablet based data collection system and uploaded to a centralised server in real time using proprietary software. A quality control team did extensive data quality checks to ensure data completeness and validity.

Data cleaning

Data was first cleaned and later analysed using Stata 14.0 for windows (85). Anthropometric data were cleaned in two stages.

First, potential useful variables were recognized and controlled. This involved checking length and weight of the infants for outliers. Since weight and length measurement of infants were taken directly from the RHC, inter- and intra-rater reproducibility of the measurements were not assessed by the study team.

Therefore, all anthropometric data of children was checked and consequently removed if there were errors in the recording of the data. It should be noted that this was done in dialogue with a statistician and the research leader of KIBS II.

The variation in measurement quality and number of measurements was large across clinic visits and therefore only weight and length from the day the study team was present is used in the analysis, corresponding to two age groups of children in KIBS II. The distribution of anthropometric measurements from possible contact points using the RHC and from the KIBS II data collection is given in Figure 5 for KIBS 2a and Figure 6 for KIBS 2b. See appendix 2 – illustrations for more information about the distribution of measurement data. The study team presence at the site is a likely reason for increased number of weight and length measurements performed at the time of interview. Participants were asked to do weight and length measurements before being interviewed, specifically.

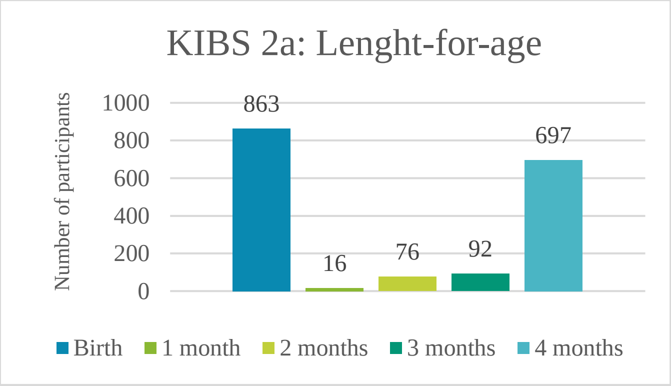

Figure 5. Displaying the variation in number of length measurements done between birth and 13-15 weeks (4 months in figure)

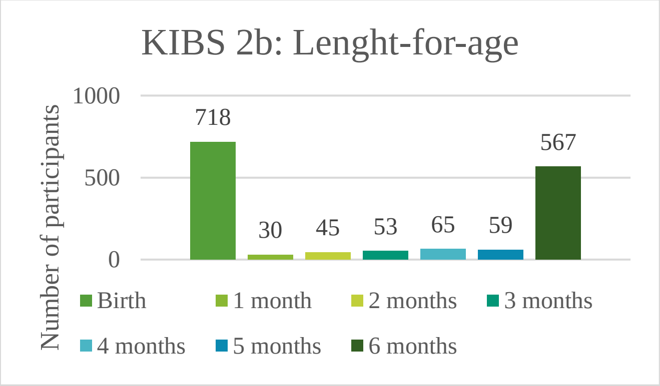

Figure 6. Displaying the variation in number of length measurements done between birth and 6 months

Second, the anthropometric data cleaning was based on attained z-scores from the WHO Child Growth Standards. Measurements were flagged at the following criteria:

1. WAZ <-6 or >5;
2. LAZ <-6 or >6;
3. WLZ <-5 or >5 or
4. WLZ > WLZ >3 and LAZ <-3.

Measurements were set to missing if one or more of these extreme values existed after being assessed individually.

Statistical analysis

The infants were analysed in two separate groups: KIBS 2a (14 weeks) and KIBS 2b (6 months). These infants are not related other than interviewed in the same clinic during the data collection period. The Stata command “zscore06” was used to calculate the different z-scores (86). The Stata svy-command was used to control for clustering which was clinics in this study.

Descriptive statistics

The descriptive statistics consists of a baseline table showing the general characteristics and distribution of the population. A separate infant feeding table was made to give more information about the distribution of type of feeding and breastfeeding habits. Furthermore, information about HIV status and the rate of breastfeeding is given for mothers only in both KIBS 2a and 2b. Finally, the basic anthropometric measurements are listed and described before continuing with the risk factor analysis. Categorical data are presented with percentages, while continuous data are presented with means, standard deviations and confidence intervals.

Risk factor analysis

The dependent variables used for the analysis were: WAZ, LAZ and WLZ, with cut-offs at < -2 and >2 z-scores. WLZ < -2 indicates wasting, LAZ < -2 indicates stunting, WAZ < -2 indicates underweight, and WLZ > 2 indicates overweight. The dependent variables were used as continuous variables for the linear regression analysis. Dependent dichotomous variables were constructed using the cut-offs above for logistic regression analysis.

Potential associated determinants were assessed by crude and adjusted analysis. In the first round, simple linear regression and logistic regression analysis were performed separately displaying crude values for each variable analysis. In the second round, the estimates were adjusted for potential confounding factors according to a conceptual hierarchical framework which was based on the Conceptual UNICEF framework on young child malnutrition from 1991 (21). Figure 7 shows the factors controlled for in all models of linear and logistic regression. The adjusted multivariable analysis included the inherent factors age and gender in all models through all analytical stages. Furthermore, other variables remained in the model for the next analytical stage if they were significant at the $p<0.05$ level in the previous analytical stage. The first analytical stage consisted of the immediate factors breastfeeding and complementary feeding, next to the underlying factors age and gender. If any of the immediate variables appeared significant, they were included in the next analytical stage where intermediate factors were applied next to the inherent factors. This continued for the next analytical stage, including the distal factors and finally the underlying factors

Both crude and adjusted linear and logistic regression analysis were done for each of the dependent variables WAZ, LAZ, and WLZ according to KIBS 2a and KIBS 2b. Based on the principles described above, child growth including continuous and dichotomous data with in total three dependent variables which resulted in 18 multivariable models. Only adjusted models where the dependent dichotomous variable had a prevalence of more than 20% in the population at end-point, e.g. stunting >20% are presented. The risk factor analysis is therefore presented for major public health problems. All tables of linear and logistic regression models crude and adjusted are given in appendix 3 – Risk factor analysis.

Following is a brief explanation of the independent variables used in the framework, illustrated in Figure 7.

- Breastfeeding: is represented by “Any breastfeeding” and is divided into; never, stopped and still. Stopped and still refers to whether they had stopped breastfeeding or continued breastfeeding at the time of interview.
- Formula feeding: is measured by “formula ever given”, this was done because more than 40% of the infants had received infant formula at some time point between birth and the time of the interview, compared to any other foods given/asked for.
- Birthweight: is measured as a continuous variable in the framework.
- HIV status of mother: HIV status was self-reported, and defines the baby as being HIV exposed.

- Breastfeeding within 1 hour after delivery: This was asked in the interview to mothers only as other caregivers might not know this. It is presented as a categorical variable either within or after one hour after delivery.
- Household information: gives an idea of the living situation of the participants.
    - Water private/public: access to water is dependent on were the participant lives and might not be something they can improve themselves. The variable is presented as a categorical variable with either having a public or a private water source.
    - Toilet flush/other: The variable is divided into having a flush toilet or other: bucket toilet, bush/veld/no toilet. The variable is presented as a categorical variable, having either a flush toilet or other types.
    - Electricity: as for water, electricity access is dependent on where the participant lives and might not be something the participant can improve themselves. Presented electricity versus non-electricity.
    - Cooking on electricity: If not cooking on electricity the participant might cook on other fuels: gas, coal, wood, cow dung, paraffin or other. Cooking on something else than electricity may happen inside or outside the residence. Presented cooking on electricity or other.
- Child support grant: The child support grant is on 350 rand, which is approximately 23,5€ or 29,2$. This is given by the government to all mothers when applied for. Presented yes/no.
- Siblings: This was reported as a categorical variable, with either having siblings or not.
- Mothers information:
    - Research has showed that age of mother, BMI and education level may affect the nutritional status of their children. This information was recorded in the interview. Age of mother and BMI are presented as continuous variables, while education level is presented as a categorical variable.
    - Relationship status with father may say something about his involvement, and thereby if they are two caretaker of the child or not. Presented as a categorical variable.

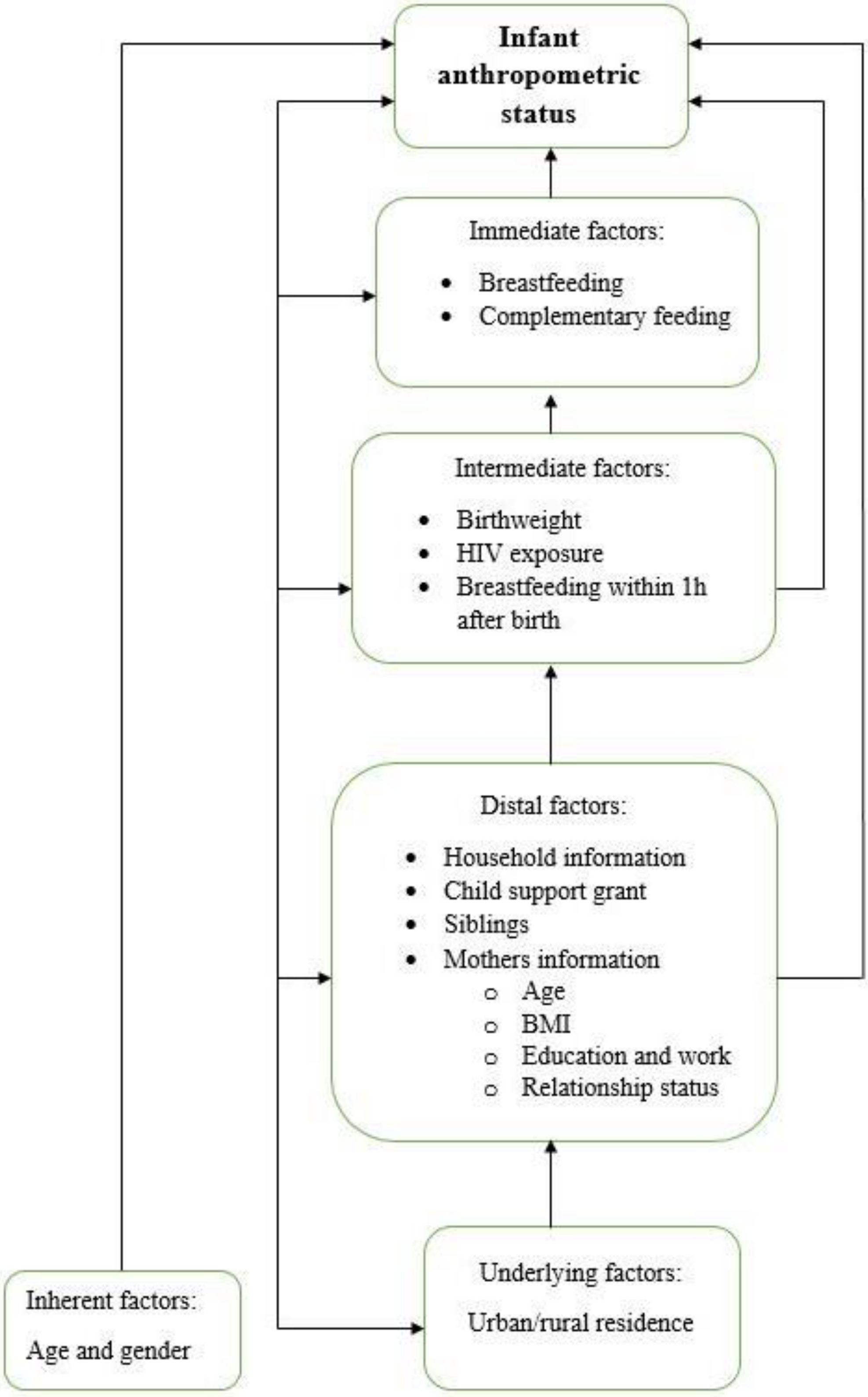

Figure 7. Hierarchical framework on malnutrition based on UNICEF framework on young child malnutrition from 1991 (21)

Post estimation testing

After performing the statistical analysis, several post estimation test were performed to control whether the models were made correctly. The Wald test (overall likelihood ratios test) was used to check if the variables used in the models contributed to the overall model fit. This is done by testing if the corresponding beta coefficient is statistically different from zero (or any other value under the null hypothesis) (87). If the p-value is <0.05, the variables contributing are statistically significant improving the model. The linktest was developed by Pregibon (1979) and is used to test the model specification (88). If the _hatsq turns out non significant, it confirms that the model was correctly specified. Finally, the Hosmer-Lemeshow Goodness-of-Fit test was used to test for the goodness-of-fit of a fitted logistic regression model. If the values is not significant, it indicates a good fit.

Results

Descriptive statistics

Study population

The study-profile, displayed in Figure 8, show the number of infants remaining for analysis with WAZ, LAZ and WLZ as dependent variables. The number of participants within each category of z-score is different both due to the large variation of measurements performed and due to the WHO anthropometric cut-off applied.

Of the 929 children in KIBS 2a, 118 (12.7%) were excluded within WAZ, 232 (25%) were excluded within LAZ and 272 (29.3%) were excluded for WLZ from the anthropometric analysis due to incomplete data on weight and height or had extreme outliers. Of the 774 in KIBS 2b the corresponding numbers were 56 (7.2%), 207 (26.7%), and 217 (28%) for WAZ, LAZ and WLZ, respectively.

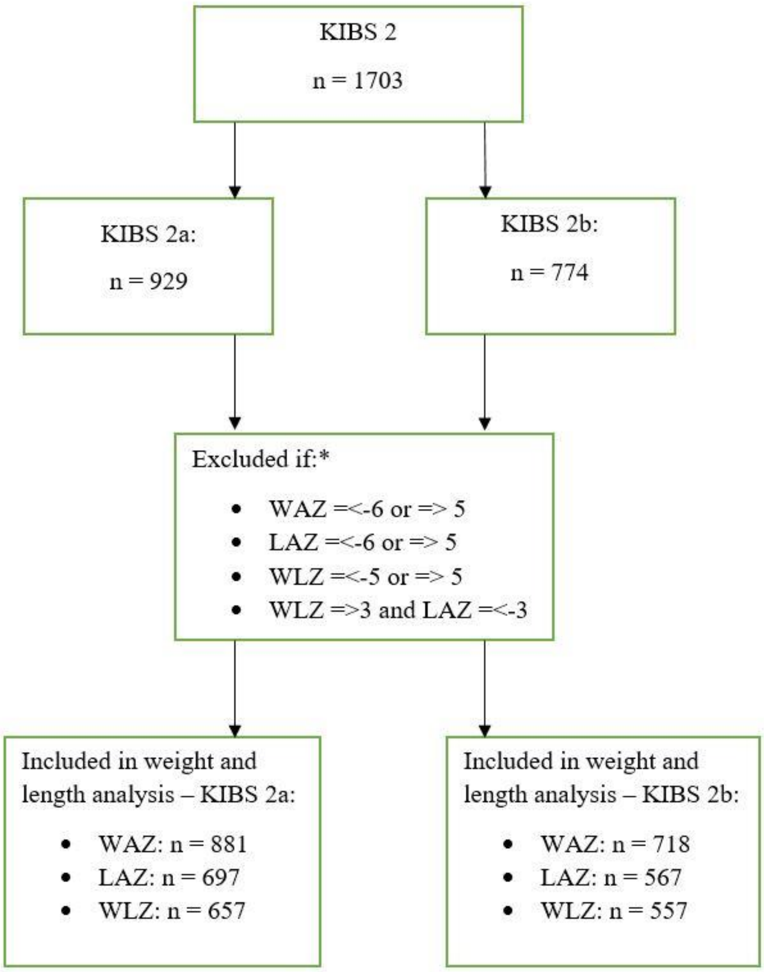

Figure 8. Study profile. *WHO anthropometric criteria

Baseline table

A total of 1703 caregivers were interviewed attending 30 fixed and mobile clinics in 11 districts of KZN between January and May 2017. 1393 (81.8%) mothers and 310 (18.2%) other caregivers (grandmother, father, other relative) were interviewed. The caregivers were asked to report on behalf of the child if possible to give an answer. The target age of the infant was either 14 weeks (13-15 weeks) or 6 months (24-30 weeks), referred to as KIBS 2a and KIBS 2b, respectively. Birthweight is divided into low, normal and macrosomia according to definitions by UNICEF and WHO, with 10.7% in KIBS 2a and 12.9% in KIBS 2b being born with a low birthweight (89). The mean age of mothers participating in the study was 26.4 years old, while for other caregivers this was 35.8 years old. The baseline table constitutes all participants in the study, before excluding any for anthropometrical analysis. General baseline characteristics were similar for participants in KIBS 2a and KIBS 2b.

Table 1. Baseline characteristics including all participants (n=1703), except when maternal information only is given (n= 1393) or non-maternal (n= 310)

	KIBS 2a (n= 929)		**KIBS 2b (n=774)**	
Categorical data	n	%	n	%
Female child	457	49.2	386	49.9
Birthweight in categories				
Low birthweight (<2500g)	88	10.7	92	12.9
Normal birthweight (2500 - 4000g)	722	87.4	604	85.0
Macrosomia (≥4000g)	15	1.8	14	2.0
Siblings				
No	339	36.5	235	30.4
Yes	449	48.3	370	47.8
Missing answer (non-maternal)	141	15.2	169	21.8
Mother of the baby				
No	141	15.2	169	21.8
Yes	788	84.8	605	78.2
HIV status mother				
Negative	472	50.8	355	45.9
Positive	303	32.6	238	30.8
Maternal age				
<20	118	12.7	102	13.2

20-24	253	27.2	211	27.3
25-29	234	25.2	177	22.9
30-49	324	34.9	284	36.7
Mother living with baby				
No	54	5.8	79	10.2
Yes	875	94.2	695	89.8
Mother in relationship with father				
No	39	4.2	59	7.6
Yes	740	79.7	538	69.5
Living in rural or urban area				
Rural	588	63.3	574	74.2
Urban	341	36.7	200	25.8
Mothers highest school grade				
0-7	53	5.7	42	5.4
8-12	735	79.1	563	72.7
Mother returned to school				
No	312	33.6	256	33.1
Yes	38	4.1	44	5.7
Mother is currently working				
No	723	77.8	523	67.6
Yes	65	7.0	82	10.6
Household information				
<u>Water</u>				
Water - private	596	64.2	435	56.2
Water - public	321	34.6	327	42.2
<u>Toilet</u>				
Toilet - flush toilet	343	36.9	226	29.2
Toilet - other	574	61.8	536	69.3
Electricity in house	818	88.1	651	84.1
Cooking - electricity	726	78.1	553	71.5
Maternal BMI (kg/m^2)				
Underweight (<18,5)	14	1.5	19	2.5
Normal (18,5 - 24,9)	240	25.8	181	23.4

Overweight (25 - 29,9)	213	22.9	163	21.1
Obesity I (30 - >40)	207	27.4	144	18.6
Continuous data	**Mean**	**C.I (SD)**	**Mean**	**C.I**
Mothers age (n=1393)	26.4	15.0-45.0 (6.3)	26.5	15.0-46.0 (6.4)
Other caregivers age (n=310)	35.8	15.0-69.0 (12.3)	36.1	16.0-75.0 (13.3)
Maternal BMI (average kg/m^2)	27.9	14.5-54.1(6.1)	27.5	12.5-57.3 (6.2)
Birthweight (kg)	3.05	3.0-3.1 (0.02)	3.04	3.0-3.1 (0.02)

Infant feeding practices

Table 2 shows reported feeding practices among maternal participants only. A 24h recall was also performed during the interview concerning infant feeding, the results of this can be found in appendix 1 – infant feeding.

Initiation of breastfeeding later than one hour was 41.3% in KIBS 2a and 33.9% in KIBS 2b. In KIBS 2a, 75.8% of the mothers were still breastfeeding their child at 14 weeks of age. In KIBS 2b, 70.7% of the mothers were still breastfeeding their child at 6 months. 17.3% in KIBS 2a and 22.6% in KIBS 2b had stopped breastfeeding their child at the time of the interview.

Table 2. Mothers responses on infant feeding practices stratified by child age (n= 1393)

	KIBS 2a		**KIBS 2b**	
	n	%	n	%
n total	788		605	
Initiation time breastfeeding after delivery				
Within 1hr	347	37.6	292	37.8
After 1hr	382	41.3	262	33.9
Don't remember	195	21.1	219	28.3
Breastfeeding				
Never	55	7.0	40	6.6
Stopped	136	17.3	137	22.6
Still	597	75.8	428	70.7
Complementary feeding				
Formula ever given				
No	526	66.7	351	58.0
Yes	258	32.7	252	41.6
Water ever given				
No	612	77.7	290	48.0
Yes	171	21.7	313	51.7
Traditional vitamins				
No	707	89.7	511	84.5
Yes	77	9.8	92	15.2

HIV positive mothers

Of the 1393 mothers surveyed, 1368 were tested during their last pregnancy and were able to report their HIV status; 827 (60.5%) were HIV negative and 541 (39.5%) mothers were HIV positive. Of the HIV positive mothers, 538 (99.4%) were currently on antiretroviral treatment.

At the time of interview, 12.9% of the HIV positive mothers said they had never breastfed (BF) their child while only 3.4% of the HIV negative mothers had never done this in KIBS 2a. For KIBS 2b this was 6.7% and 6.5% respectively.

Table 3. KIBS 2a – HIV and breastfeeding (n= 929)

	HIV positive		**HIV negative**		**Missing status**	
	n	%	n	%	n	%
Still BF	197	65.0	390	82.6	11	7.1
Stopped BF	67	22.1	66	14.0	6	3.9
Never BF	39	12.9	16	3.4	1	0.6
Missing	-	-	-	-	136	88.3
Total	303	100	472	100	154	100

Table 4. KIBS 2b – HIV and breastfeeding (n= 761)

	HIV positive		**HIV negative**		**Missing status**	
	n	%	n	%	n	%
Still BF	155	65.1	263	74.1	11	6.1
Stopped BF	67	28.2	68	19.1	2	1.1
Never BF	16	6.7	23	6.5	1	0.5
Missing	-	-	1	0,3	167	92.3
Total	238	100	355	100	168	100

Anthropometric measurements

The average weight at birth was 3050 grams and the average length was 49.6cm, showed in Table 5, for the infants in KIBS 2a. While this was 3040 grams and 49.0 cm in KIBS 2b, showed in Table 8. Table 6 and 9 shows the mean z-score value at birth and end-point for KIBS 2a and KIBS 2b, respectively.

Table 7 and 10 shows the distribution of z-scores within the different categories WAZ, LAZ and WLZ. The values underlined are marked because they show more than 20% of the children either having a z-score below -2 or above 2. Illustrations of Tables 7 and 10 can be found in appendix 2 – illustrations.

According to the results, more than 20% of the children were born with a low birthweight compared to length in both KIBS 2a and KIBS 2b. Furthermore, approximately one in ten were classified as stunted.

With a cut-off below -2, for KIBS 2a, 12.8% were underweight, 42.9% were stunted and 5.5% were wasted. In KIBS 2b, 4.9% were underweight, 21.7% were stunted and 3.6% were wasted. In KIBS 2a, 28.0% were overweight and in KIBS 2b this was 21.9%.

KIBS 2a

Table 5. KIBS 2a – mean weight and length at birth and at time of interview

		Weight (kg)			**Length (cm)**
	n total	Mean (95%CI)		n total	Mean (95%CI)
Birth	825	3.05 (3.0 to 3.1)	**Birth**	867	49.6 (49.4 to 49.8)
14 weeks	885	6.27 (6.2 to 6.3)	**14 weeks**	735	58.6 (58.3 to 58.9)

Table 6. KIBS 2a – average z-score values

	n total	**Mean (95%CI)**
WAZ		
Birth	825	-0.34 (-0.39 to -0.29)
14 weeks	881	-0.40 (-0.45 to -0.34)
LAZ		
Birth	863	-0.02 (-0.09 to 0.05)
14 weeks	697	-1.01 (-1.09 to 0.94)
WLZ		
Birth	750	-0.55 (-0.63 to -0.48)
14 weeks	657	0.59 (0.51 to 0.68)

Table 7. KIBS 2a – distribution of z-scores within categories WAZ, LAZ and WLZ

	WAZ		**LAZ**		**WLZ**	
	Birth	14 weeks	Birth	14 weeks	Birth	14 weeks
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
n total	825	881	863	697	750	657
<-2	71 (8.6)	113 (12.8)	81 (9.4)	<u>299 (42.9)</u>	184 (24.5)	36 (5.5)
<-1	176 (21.3)	203 (23.0)	134 (15.5)	154 (22.1)	167 (22.3)	45 (6.8)
0	543 (65.8)	498 (56.5)	452 (52.4)	205 (29.4)	307 (40.9)	252 (38.4)
>1	32 (3.9)	55 (6.2)	112 (13.0)	31 (4.5)	65 (8.7)	140 (21.3)
>2	3 (0.4)	12 (1.4)	84 (9.7)	8 (1.1)	27 (3.6)	<u>184 (28.0)</u>

<u>Underlined</u> means the values is used in the risk analysis

KIBS 2b

Table 8. KIBS 2b – mean weight and length at birth and at time of interview

		Weight (kg)			**Length (cm)**
	n total	Mean (95%CI)		n total	Mean (95%CI)
Birth	710	3.04 (3.00 to 3.08)	**Birth**	720	49.0 (49.4 to 49.6)
6 months	720	7.84 (7.75 to 7.93)	**6 months**	581	65.5 (65.1 to 65.8)

Table 9. KIBS 2b – average z-score values

	n total	**Mean (95%CI)**
WAZ		
Birth	710	-0.35 (-0.41 to -0.29)
6 months	718	0.13 (0.07 to 0.20)
LAZ		
Birth	718	0.004 (-0.07 to 0.08)
6 months	567	-0.35 (-0.44 to -0.25)
WLZ		
Birth	750	-0.55 (-0.63 to -0.48)
6 months	557	0.47 (0.39 to 0.56)

Table 10. KIBS 2b – distribution of z-scores within categories WAZ, LAZ and WLZ

	WAZ		**LAZ**		**WLZ**	
	Birth	6 months	Birth	6 months	Birth	6 months
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
n total	710	718	718	567	626	557
<-2	77 (10.8)	35 (12.4)	67 (9.3)	123 (21.7)	148 (23.6)	20 (3.6)
<-1	136 (19.2)	89 (12.4)	105 (14.6)	92 (16.2)	128 (20.5)	45 (8.1)
0	459 (64.6)	396 (55.1)	376 (52.4)	250 (44.1)	280 (44.7)	266 (47.8)
>1	34 (4.8)	142 (19.8)	98 (13.7)	62 (10.9)	45 (7.2)	104 (18.7)
>2	4 (0.6)	56 (7.8)	72 (10.0)	40 (7.1)	25 (4.0)	122 (21.9)

Underlined means the values is used in the risk analysis

Risk analysis - Factors associated with anthropometric measurements.

Only adjusted tables are displayed if the prevalence is more than 20% as a part of the risk analysis presented in the method where Stage 1 is inherent, 2 is immediate, 3 is intermediate, 4 is distal and 5 is underlying factors. Stage 1, sex and age, is carried forward in each model irrespective of significant status. This shows factors which interplay and may affect the outcome of either length-for-age z-score <-2 or a weight-for-length z-score of >2. All full tables, both crude and adjusted tables, can be found in appendix 3 – risk factor analysis, linear and logistic regression.

First, the results from LAZ adjusted linear and logistic regression (LAZ <-2) is displayed for both KIBS 2a and KIBS 2b, then the results from WLZ >2 in the same order. The bold values mean that they are statistically significant at the 0.05 level. OR means odds ratio and β is the linear regression coefficient.

KIBS 2a – LAZ

Table 11. KIBS 2a – Adjusted linear regression LAZ

Adjusted LAZ	**Stage 1**		**Stage 2**		**Stage 3**		**Stage4**		**Stage 5**	
	β	95% CI	β	95% CI	β	95% CI	β	95% CI	β	95% CI
Sex, female	**0.42**	**0.11; 0.73**	**0.37**	**0.02; 0.73**	**0.45**	**0.13; 0.77**	**0.61**	**0.24; 0.97**	**0.57**	**0.30; 0.83**
Age (days)	-0.00	-0.04; 0.03	-0.01	-0.05; 0.03	-0.00	-0.04; 0.04	-0.01	-0.06; 0.04	-0.00	-0.04; 0.03
Birthweight, kg					**1.13**	**0.78; 1.47**	**1.10**	**0.69; 1.51**	**1.02**	**0.72; 1.31**
HIV positive mother					**-0.40**	**-0.73; -0.08**				
Water, private source							**-0.76**	**-1.47; -0.05**	**-0.64**	**-1.24; -0.05**

Bold means statistical significant at p-value <0.05

Table 12. KIBS 2a – Adjusted logistic regression LAZ, with cut-off <-2

Adjusted LAZ	**Stage 1**		**Stage 2**		**Stage 3**		**Stage 4**		**Stage 5**	
	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI
Sex, female	**0.60**	**0.41; 0.87**	**0.63**	**0.41; 0.98**	**0.53**	**0.35; 0.81**	**0.41**	**0.21; 0.83**	**0.48**	**0.33; 0.69**
Age (days)	1.00	0.97; 1.04	1.01	0.97; 1.05	1.00	0.96; 1.05	1.03	0.96; 1.11	1.01	0.97; 1.05
Birthweight, kg					**0.29**	**0.18; 0.46**	**0.22**	**0.09; 0.50**	**0.33**	**0.20; 0.53**
HIV positive mother					**1.8**	**1.24; 2.60**				
Electricity in house							**0.34**	**0.12; 0.97**		
Cooking on electricity							**3.86**	**1.15; 12.96**	**2.44**	**1.27; 4.69**

Bold means statistical significant at p-value <0.05. OR = Odds ratio.

KIBS 2b – LAZ

Table 13. KIBS 2b – Adjusted linear regression LAZ

Adjusted LAZ	Stage 1		Stage 2		Stage 3		Stage4		Stage 5	
	β	95% CI	β	95% CI	β	95% CI	β	95% CI	β	95% CI
Sex, female	**0.46**	**0.11; 0.81**	**0.49**	**0.11; 0.88**	**0.55**	**0.18; 0.93**	**0.56**	**0.20; 0.92**	**0.63**	**0.27; 0.97**
Age (days)	-0.00	-0.02; 0.01	-0.00	-0.02; 0.02	0.01	-0.01; 0.02	0.01	-0.01; 0.03	0.00	-0.01; 0.02
Birthweight, kg					**0.85**	**0.50; 1.20**	**0.78**	**0.31; 1.24**	**0.86**	**0.52; 1.20**
Child support grant							**-0.89**	**-1.63; -0.15**	**-0.67**	**-1.28; -0.06**

Bold means statistical significant at p-value <0.05.

Table 14. KIBS 2b – Adjusted logistic regression LAZ, with cut-off <-2

Adjusted LAZ	Stage 1		Stage 2		Stage 3		Stage 4		Stage 5	
	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI
Sex, female	0.70	0.44; 1.12	0.64	0.36; 1.11	**0.51**	**0.30; 0.86**	0.78	0.35; 1.75	**0.63**	**0.40; 0.98**
Age (days)	1.00	0.98; 1.02	1.00	0.97; 1.03	1.00	0.97; 1.03	0.99	0.95; 1.02	1.00	0.97; 1.03
Birthweight, kg					**0.31**	**0.16; 0.58**	**0.32**	**0.13; 0.81**	**0.33**	**0.19; 0.60**

Bold means statistical significant at p-value <0.05. OR = Odds ratio.

KIBS 2a – WLZ

Table 15. KIBS 2a – Adjusted linear regression WLZ

Adjusted WLZ	Stage 1		Stage 2		Stage 3		Stage 4		Stage 5	
	β	95% CI	β	95% CI	β	95% CI	β	95% CI	β	95% CI
Sex, female	-0.09	-0.35; 0.17	0.00	-0.28; 0.28	0.02	-0.29; 0.33	-0.01	-0.55; 0.52	-0.09	-0.34; 0.16
Age (days)	0.02	-0.01; 0.06	0.01	-0.01; 0.04	0.02	-0.01; 0.05	0.02	-0.02; 0.06	0.03	-0.01; 0.06
Birthweight, kg					**0.37**	**0.03; 0.71**				

Bold means statistical significant at p-value <0.05.

KIBS 2a – WLZ > 2

Table 16. KIBS 2a – Adjusted logistic regression WLZ >2

Adjusted WLZ	Stage 1		Stage 2		Stage 3		Stage 4		Stage 5	
	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI
Sex, female	0.98	0.75; 1.30	1.13	0.80; 1.60	1.13	0.78; 1.64	1.24	0.59; 2.63	0.98	0.74; 1.29
Age (days)	1.04	0.99; 1.08	1.02	0.98; 1.07	1.03	0.98; 1.08	1.03	0.97; 1.10	**1.04**	**1.00; 1.09**

Bold means statistical significant at p-value <0.05. OR = Odds ratio.

KIBS 2b – WLZ

Table 17. KIBS 2b – Adjusted linear regression WLZ

Adjusted WLZ	Stage 1		Stage 2		Stage 3		Stage 4		Stage 5	
	β	95% CI	β	95% CI	β	95% CI	β	95% CI	β	95% CI
Sex, female	-0.06	-0.37; 0.26	-0.06	-0.45; 0.32	0.12	-0.24; 0.49	0.17	-0.35; 0.70	0.04	-0.26; 0.34
Age (days)	0.01	-0.01; 0.03	0.01	-0.01; 0.03	0.01	-0.00; 0.03	0.01	-0.02; 0.03	0.01	-0.00; 003
Birthweight, kg					**0.62**	**0.32; 0.92**	**0.88**	**0.36; 1.40**	**0.58**	**0.31 0.86**

Bold means statistical significant at p-value <0.05.

KIBS 2b – WLZ > 2

Table 18. KIBS 2b – Adjusted logistic regression WLZ >2

Adjusted WLZ	Stage 1		Stage 2		Stage 3		Stage 4		Stage 5	
	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI
Sex, female	0.95	0.64; 1.42	0.89	0.53; 1.48	1.18	0.65; 2.13	1.48	0.56; 3.86	0.96	0.63; 1.45
Age (days)	1.01	0.99; 1.03	1.00	0.97; 1.02	1.00	0.97; 1.03	0.99	0.97; 1.02	1.01	0.99; 1.03
Birthweight, kg					**2.09**	**1.44; 3.03**				

Bold means statistical significant at p-value <0.05. OR = Odds ratio.

Length for age risk analysis

Sex, birthweight, HIV status of mother and private water source were significantly associated with the length-for-age adjusted linear regression for KIBS 2a, displayed in Table 11. In the adjusted logistic regression with cut-off below -2, sex, birthweight, HIV status of mother, electricity in house and cooking on electricity were significant, showed in Table 12. Estimates indicate that the odds ratio of becoming stunted is lower for female children than for male children at all analytical stages in KIBS 2a. The fifth analytical stage showed an odds ratio of 0.48 (0.33; 0.69) for KIBS 2a.

Mother's positive HIV status only turned out significant in the third analytical stage for KIBS 2a in both linear and logistic regression for linear and stunted growth, respectively. The variable did not remain in any of the two models for linear and logistic regression.

For KIBS 2b, both birthweight and child support grant were significant for stunted growth when performing the adjusted linear regression, displayed in Table 13. Indicating a possible connection between this and length-for-age outcome. In the adjusted logistic regression, sex was significant in most of the analytical stages indicating female sex to be protective of becoming stunted, displayed in Table 14. In the fifth analytical stage for sex in KIBS 2b the OR was 0.63 (0.27; 0.97). Birthweight was significant for a length-for-age cut-off below -2 in all analytical stages after introduction, indicating the odds of becoming stunted to be lower if birthweight was normal.

There were some unexpected findings regarding variables used as a proxy for socio-economic factors. Private water source turned out to be a negative factor for stunting in KIBS 2a, next to cooking on electricity, while having electricity in the house was a protective factor against stunting. In KIBS 2b, receiving child support grant seemed to be negatively associated with stunted growth.

Overweight risk analysis

Only birthweight was significant at the third analytical stage in the adjusted linear regression for WLZ showed in Table 15, but did not remain significant in the next analytical stage in KIBS 2a. However, it continued to remain in the model in KIBS 2b showed in Table 17, with a β of 0.58 (0.31; 0.86) at the fifth analytical stage.

Only birthweight was significant in the third analytical stage of the adjusted logistic regression model in KIBS 2b, displayed in Table 18, with an OR of 2.09 (1.44; 3.03), and no values in KIBS 2a, showed in Table 16. However, birthweight did not remain significant throughout the analytical stages for KIBS 2b.

Post estimation test

The overall likelihood ratios test was performed on logistic models to test the models significance. All models came back significant except for WLZ > 2. For the model specification, the linktest was used. The _hatsq was not significant for any of the models, hereby indicating correctly specified models. The "Hosmer and Lemeshow Goodness-of-fit" statistic was not significant for any of the models, except WLZ >2 indicating a good fit for all models except for the WLZ >2.

Discussion

The general objective of this thesis was to describe attained growth and nutritional status expressed as WAZ, LAZ and WLZ among 14 weeks and six month old infants participating in KIBS II survey in KwaZulu-Natal, South Africa. South Africa is a country that has had high prevalences of malnutrition and with increasing rates of overweight among both children and adults in recent years. The analysis reviled high prevalences of stunting and overweight in both KIBS 2a and KIBS 2b.

Main findings

Anthropometry

In KIBS 2a, more than 40% were categorized as stunted, while one in twenty were wasted and one in ten were underweight. In KIBS 2b, more than 20% were stunted, and the same prevalence of wasting and underweight was found here as for KIBS 2a. The main difference in stunting between the two survey populations will be discussed.

Compared to z-scores at birth, children gained weight quickly while length growth seemed to take longer time. One in five had a low birthweight relative to birth length in both KIBS 2a and KIBS 2b, but only approximately 5% were wasted at end-point. However, the overweight prevalence increased to one in five being overweight at end-point. At birth, almost ten percent were stunted, and this prevalence only increased with time in both KIBS 2a and 2b. These results suggest a challenge in length growth compared to weight gain in KZN.

Of the mothers who were measured (taken weight and length measurements), more than 40% of them had a BMI above 25 kg/m^2, with the average BMI being 27.9 kg/m^2. Of these mothers, close to 40% in KIBS 2a and 20% in KIBS 2b had a stunted child. Moreover, of the overweight mothers, 30% had an overweight child in KIBS 2a and the rate in KIBS 2b exceeded 20%.

Approximately 40% of the mothers interviewed were HIV positive. Of them, close to 50% of them had a stunted child in KIBS 2a and one in five had a stunted child in KIBS 2b. This suggests length growth challenges among HEU children. Furthermore, two thirds of the HIV positive women had a BMI above 25 kg/m^2. This is however in contrast to previous findings from South Africa, where typically low levels of overweight was found when there was a high prevalence of HIV in specific areas in KwaZulu-Natal (90).

The stunting prevalence is higher in KIBS 2a, but not in KIBS 2b, compared to numbers from the South Africa Demographic and Health Survey 2016: Key Indicator Report (SADHS). Moreover, the KIBS II analysis also found higher prevalences of wasting and underweight than found in the SADHS (37). An increase in stunting from approximately 10 to 20% seems likely looking at KIBS 2b (from birth to six months) and is in line with other South African representative data (37). Therefore, stunting rates at almost 40% in KIBS 2a may be due to methodological challenges, however the measurements were performed at the same clinics and by the same people as in KIBS 2b. In addition, measuring 14 weeks old children should not be extensively more difficult than measuring six month old children, thus one cannot rule out that the frequency is plausible.

The analysis was not performed with stratifying the undernutrition at the -3SD level for severe undernutrition in addition to -2SD when defining undernutrition. Thus, everything below -2 SD was presented as an entity. This may partially explain some discrepancies in the prevalence estimates being higher in KIBS II than found by SADHS. Furthermore, the results are limited to children up to six months, and does not show the spectrum between zero and five years of age which the SADHS does. The results from this analysis therefore only show a small part of the children under the age of five years living in KZN. The SADHS also found variation in stunting rates between ages (37), suggesting that the data used here could have changed if monitored at an older age.

The z-score of a child can change quickly dependent on nutrition status and disease, and more importantly because childhood is a period of rapid growth (91). In the first three months of life, infants gain between 2500g and 2900g on average, and in the next three months they gain between 1400g and 1500g on average. This means that children can almost double their birthweight in the first three months if being well nourished. The higher prevalence of underweight may indicate that this was not the case for children in KIBS 2a. The increase in length in the first year is on average 24-25cm for a child with a z-score around zero (92).

The double burden of malnutrition in KwaZulu-Natal

The double burden of malnutrition is clearly present in KZN as high prevalences of stunting and overweight was found at the same time in both KIBS 2a and KIBS 2b (same community). These findings are consistent with earlier findings from South Africa (39). The overweight prevalence was more than 20% in both KIBS 2a and 2b and this finding is comparable to the findings in the SADHS. Furthermore, the analysis showed that malnourished children and malnourished mothers lived in the same household.

Moreover, in KIBS 2a, the rate of children classified as overweight and stunted at the same time exceeded 70%. In KIBS 2b this rate was slightly lower, but still more than 40% of the children were both overweight and stunted. A study from Indonesia found children who were stunted to have a larger odds ratio of being overweight compared to non-stunted children, moreover, this finding was also higher among younger children (< 3 years) than older children (93).

According to analysis by de Onis et al. (94) on the prevalence of childhood overweight in the world, the majority of children with overweight or obesity live in developing countries. Changes in dietary and physical activity over time might be one of the reasons for this increase in prevalence of early childhood overweight and obesity which the world is facing now (22). The current analysis from KIBS II confirms earlier trends toward childhood obesity, and that it can start already when the child is only six months of age (95).

Rapid weight gain early in life has showed to be a risk factor for later insulin resistance, obesity and cardiovascular disease, particularly among formula fed infants (96). Another study from KZN confirms these findings, which found inappropriate infant feeding practices despite presence of community health workers who should promote breastfeeding and give education about nutrition. Examples of these eating patterns were: incorrect preparation of formula feeds, frequent consumption of savoury snacks and early introduction of complementary foods (97). Moreover, the 24h recall in KIBS II (appendix 1) showed that less than one percent of the children in KIBS 2a and five percent in KIBS 2b had received sugar or sweets at the time of the interview. Other types of food given were cereal, bread/rice/porridge, egg, fruit and vegetables.

The overall breastfeeding rate is relatively high with more than 70% in both KIBS 2a and KIBS 2b still breastfeeding at the time of the KIBS survey questionnaire. Breastfeeding is recommended to continue until the child is 24 months old, but with introduction of complementary food when the child might need more/other food than breastmilk to become satiated. From the age of six months, it is common to introduce complementary foods to the child. This is also a time where linear growth has been observed to falter as children have to adapt to these new tastes and textures (98). There were higher percentages of infants who had received formula or water at the time of question in KIBS 2b than in KIBS 2a, which can be explained by the age difference. Moreover, formula and water could have been given next to breastfeeding, especially in KIBS 2a, which was the case in KIBS 1 (83).

This would lead to the child receiving more energy and a higher protein content in total than if breastmilk was given exclusively. Even though no distinguish was made between exclusive breastfeeding and mixed feeding (breastfeeding plus giving other food/drinks) in the analysis, one can hypothesis that some practiced mixed feeding possible because of the prevalence of high WLZ scores. This suggests that the children would have received higher energy from both formula and other snacks.

Rollins et al. (99) looked into exclusive breastfeeding rate and diarrhoeal morbidity and mortality among infants in KZN and found significantly fewer diarrhoeal events and burden of days among those infants who were exclusively breastfed compared to never breastfed, but also compared to those who had received mixed feeding. Danaei et al. (100) found in their report on risk factors for childhood stunting that 7.2 million cases of stunting were attributable to unimproved sanitation. Making diarrhoea one of the most important determinant of stunting among the infectious diseases (22). Mixed feeding and formula feeding may therefore be an attributable fact to the stunting rates, especially if prepared under unhygienic environments. The risk analysis showed water, even though as a private source, to be unfavourable for length growth. The reason for this could be that the water source, all though private, was not clean and therefore still contributing to stunted growth.

Due to the high prevalence of overweight among mothers, and even though this study did not have the BMI of mothers before becoming pregnant, a suggestion can be made that the prevalence of overweight among women of reproductive age was high at the time. Women are giving birth to small babies, indicating a need for better antenatal care. Poor maternal nutrition during pregnancy and fetal development has been linked to higher risk of several chronic disease in the child’s lifetime. This is referred to as “fetal programming”. This field of research is connected to epigenetics, which is a theory on how genes can be modified by the environment to produces different phenotypes (101). Today there is an increasing research on this topic on how maternal health status and biology affect the offspring biology and development (102).

Mothers should be given advice on healthy eating as they are malnourished themselves and give birth to malnourished children in KZN. The report on “Ending Childhood Obesity” presented by the WHO in 2016 focuses on guidance for preconception and antenatal care as the third recommendation on ending childhood obesity (103). Specifically, recommendation 3.3 states to: “Include an additional focus on appropriate nutrition in guidance and advice for both prospective mother and fathers before conception and during pregnancy” (103).

Furthermore, in 2016, the WHO published recommendations on antenatal care for a positive pregnancy experience. This guideline highlights some of the main factors important for both a healthy pregnancy and a healthy child (104). Both the report on ending childhood obesity and guideline on antenatal care from WHO emphasises the need to design interventions targeting women of reproductive age and women who are pregnant in order to give the child the best possible start in life.

Analysis by Engle et al. (105) show that “interventions in early childhood is the most effective and cost-efficient time to ensure that all children develop their full potential”. As the double burden of malnutrition is a fact in KZN, future interventions should focus on young children, making sure they develop to their full developmental potential and preventing further increase in both stunting and overweight rates.

Risk analysis

The specific objective was to assess factors associated with growth and risk factors for over- and undernutrition. Only prevalences of more than 20% at end-point were analysed and presented in a multivariable analytical framework believed to represent a substantial public health concern. This was the case for the stunting rates in both KIBS 2a and KIBS 2b, and for the overweight rate in KIBS 2a and KIBS 2b. The risk analysis showed sex, birthweight, socioeconomic factors and HIV status of mother to be potential factors related to malnutrition, both under- and over nutrition.

Sex – inherent factor

Sex came out as significant for both adjusted linear and logistic regression in KIBS 2a and KIBS 2b on linear growth. Previous studies from sub-Saharan Africa have found higher prevalences of stunting among boys compared to girls (98, 106). This was also found in the crude analysis (see appendix 3 – risk analysis). Therefore, one can hypothesise that it is protective to be a girl when avoiding to become stunted, however, no causal relationship can be drawn from a survey. In addition, the reasons for these results are unclear. One theory, according to Wamani et al. (98), is that girls can handle environmental stress better than boys can.

Birthweight – intermediate factor

Birthweight was positively associated with stunting and overweight outcomes in the adjusted linear regression models in both KIBS 2a and 2b. The average birthweight in KIBS 2a was 3050 grams versus 3040 grams in KIBS 2b.

Birthweight represents the first 9 months of growth of the infants life, and is among others determined by uterine and genetic factors, and maternal pre-pregnancy BMI and weight gain during pregnancy (107). 10-12% of the children were born with low birthweight in KIBS 2a and KIBS 2b, which is comparable to other studies from South Africa with prevalences around 15% (108). Low birthweight is one of several factors that influences child growth and development. Low birthweight may be the result of restricted intrauterine growth and can later result in stunting and higher disease burden (109). The first 1000 days, from conception until two years of age, is an important window for growth and development. If malnutrition happens during this window, children are at greater risk of poor health and lower level of education later in life, despite the possibility of some catch-up growth (27).

Mother HIV status – intermediate factor

The infants in KIBS 2a had a higher odds of being stunted if the mother was HIV infected. This finding is confirmed in findings by Ramokolo et al. (110) who found lower mean WAZ, LAZ, WLZ among HIV infected infants in the first six months in South Africa. However, confirmation of the child's HIV status was not possible as only information about the mothers HIV status was available. Still, because 39.5% of the mothers were HIV positive, of those who were able to report or chose to answer, assumptions can be made that some of the infants also might have been infected. Furthermore, HIV-infected infants have been found to have lower birthweight which makes them more vulnerable for undernutrition (110).

The breastfeeding practices among HIV infected mothers was slightly lower than the total breastfeeding rate in KIBS II. In KIBS 2a and KIBS 2b, approximately 65% were still breastfeeding at the time of interview. Still, 12.9% had never started breastfeeding in KIBS 2a and 6.7% in KIBS 2b. As ART coverage of drugs increase, mothers are encouraged to breastfeed for at least 12 months in the new HIV and infant guidelines from 2016 (60). According to the results, close to 100% of the HIV positive mothers were on ART treatment. Despite not stratifying formula feeding according to HIV status of the mother, it can be hypothesised that a substantial number of HEU children received formula instead of breastmilk. Specifically because approximately 10% of HIV positive women never started breastfeeding in both KIBS 2a and 2b and more than 20% of these children were overweight, suggesting an increased energy intake than can be achieved by mixed feeding, and not by only giving breastmilk.

It is important to follow-up on HEU children as they have showed in studies to have poorer growth outcomes. This is likely due to higher maternal viral loads during pregnancy and after pregnancy completion (77, 111, 112). Furthermore, HEU children should be referred for HIV testing and counselling if they have poor growth outcomes and have tested negative earlier. Coordinating eMTCT services and child follow-up services in the Expended Programme on Immunization (EPI) programme could be one way to follow up HEU children more closely, however, the design of such integration is not yet available for implementation.

Socioeconomic factors – distal factors

Environmental and socioeconomic factors can influence the nutritional status of a child. For the analysis, no socioeconomic quintiles or other type of classification was created due to lack of information about this. Therefore, "household information" was analysed encompassing four main variables. Of them, in the distal factors of the risk analysis, water source, electricity access, cooking source and financial aid (child support grant) were factors associated with linear growth in both KIBS 2a and KIBS 2b. These variables were used as a proxy for socio-economic status and suggested that socio-economic status had an impact on the nutritional status of children, which is confirmed by other studies done in sub-Saharan African countries.

The associations from the household information variables were somewhat unexpected, which could suggest that the variables were not giving a good indication alone. The results could possibly have been different if the factors had been combined in one collective variable for socio-economic factors, specifically because this study confirms how several of the other factors interplay to affect the nutritional status of children.

Methodological considerations

Evaluation of anthropometrical data

Anthropometrical measurements, both length and weights, are important measurements for child growth monitoring. There were fewer participants in the category length-for-age and weight-for-length than in weight-for-age in both KIBS 2a and KIBS 2b. The reasons for this can be multifactorial. Length measurement of children can be challenging to perform, especially since infants cannot always lay still or stretch themselves completely. It is therefore wise to be two or more when placing the child on the length board and keeping the child stretched, with its head to the headboard and without any head or footwear (3).

Both length and weight measurements can be challenging to conduct if the child is restless, which is more likely in a busy clinic with much noise. Weight measurements are generally considered easier to perform as the child can be placed on a scale and only need help from the caregiver to do so. Nonetheless, weight measurements can be wrong if the scale is not calibrated or the child is still wearing clothes. Overall, it is important to be accurate when reading the values and when recording them, which might not have been done in KIBS II, as the measurements performed between birth and end-point were impossible to use due to incomplete values.

The missing amount of length measurements in KIBS 2a and KIBS 2b, illustrated in Figures 5 and 6, can also be due to the WHO guidelines not being implemented correctly yet. The figures show how length measurements have been performed at birth and when the study team was present, but not in-between when the mother would have visited the clinic for other vaccinations for the child. Length measurements are a relative new measurement to the health system in KZN. Weight, and thereby weight-for-age, has been a common measurement in the clinic. Recently, health workers have however been asked to perform length measurements as well in KZN, but its introduction has been received with varied appreciation (personal communication).

When only WAZ, and not LAZ and WLZ are recognised as important measurements of malnutrition, it can give the wrong estimates. If this is the case, it makes ground for better practice of length measuring in KZN in order to be able to say something about the true situation regarding child growth. WAZ cannot distinguish between short-stature with adequate weight and insufficient weight but adequate length for age, as showed in Figure 1 in the introduction. Length measurements are therefore important so this distinction can be made, and children can be treated in the right manner for their nutritional status.

The monitoring problem identified in this study needs serious considerations. Health staff needs training in how to perform length measurements, also on small children, and knowledge for correct interpretation.

The analysis showed stunting rates above 40% in KIBS 2a which differed from SADHS and KIBS 2b with rates at 28.5% and 21.7%, respectively. It is hard to believe that measurement is so much more difficult at 14 weeks compared to e.g. 24 weeks, so measurement error cannot explain the entire difference. The large stunting rate might be true or it might show the difficulty of doing a length measurement on 14 weeks old children, which then indicates that the child might not be fully stretched when performing the length measurement. Regular measurement and monitoring of child growth is important to identifying children at risk as early as possible so they can be treated if necessary, both weight and length measurement every time the child visits the clinic is therefore crucial. As KIBS 2a and 2b recruited two different groups of mother-child pairs, the difference is not implausible, however, in addition to the measurement error theory it is also the chance of bias.

Bias

Biases can occur in several stages in research and may lead to a deviation of the true value. This may result in the over- or under-estimation of the results and thereby hamper the internal validity (87). Recall bias is threat to the results because mothers and care-givers were asked about past events, all the way back to when the child was born which could be up to six months back in time. By example, in KIBS 2a, 41.3% of the mothers had started breastfeeding within 1h, while in KIBS 2b this was 33.9%. Because the respondent in KIBS 2b had to remember further back in time, there is a possibility that the percent of mothers who initiated breastfeeding within 1h could be higher, but that they did not remember the exact time of initiation.

When selection bias is present it is always interesting to find out who the not included people are and possibly why they are not implemented as it may limit the generalisability of the results. In this analysis, there were fewer participants in KIBS 2b than KIBS 2a. There are several possible reasons for this: mothers could have returned to work or school and might therefore not be able to take their child to the clinic for vaccination, or it can be due the fairly new inclusion of measles vaccination for six months children. Therefore, selection bias is possibly present in the study, and is giving an unrepresentative sample of the population in the KZN for the KIBS 2b data but in a lesser degree for the KIBS 2a data.

Furthermore, social desirability bias might also be a problem in the KIBS II survey. Social desirability bias is when people answer what they think is the desired or expected answer and might thereby not answer the truth. Because of the breastfeeding promotion and the benefits now becoming clear to many mothers in South Africa, there is a possibility that they felt they could not speak freely when answering questions about breastfeeding. Also, self-reported HIV is a subject to bias as participants might not tell the truth about their status due to embarrassment or some other reason. Therefore, there is a question on whether the results of breastfeeding among HIV positive mothers is a real difference in contrast to HIV negative mothers or a reporting difference.

Overall, the results relies on participants' recall of events and presented self-reported data. Furthermore, because non-maternal caregivers also were included for some of the questions, the information about infant feeding might be less accurate compared to asking the mother.

Limitations

There are some limitations in this thesis. Firstly, only assumptions and no causal relationship can be established of infant growth due to the cross-sectional design of the study.

Secondly, all weight and length measurement data were taken directly from the RTC. Ideally, a trained team of staff would have done the measurements to ensure the measurements were performed according to the standard. However, because our data are operational data this was not possible. Moreover, these data give us an impression of the true situation on how the measurements are performed in a busy clinic and how it may affect the accuracy and quality of the data plotted in the RTC.

Thirdly, only one measure of growth after birth was available, which makes it difficult to assess how the children have developed in terms of growth and shows only a snapshot of the situation in KZN. Ideally, having more measurements in time of weight and length one could have facilitated for longitudinal growth analysis or velocity analysis.

Finally, the HIV status of the child was not documented and could therefore not distinguish between HEI, HEU and HUU children.

Strengths

Despite the limitations, the number of participants in the KIBS survey gives strength to the results next to random sampling and a large sampling frame.

Furthermore, the theoretical framework used in the risk analysis shows how several factors interplay to affect the nutritional status of children in KZN, and hereby recognises that malnutrition is not the cause of a single event or factor.

Two different age group were analysed, which gives more diversity to the results next to the fact that KIBS 2b gives an estimation of what might happen to the infants in KIBS 2a. The stunting rate in KIBS 2a was more than 40%, but was around 20% in KIBS 2b. This suggest that there might be a catch-up growth, or at least improvement in nutritional status with age.

The data are operational data, which gives an impression of the true situation in clinics in KZN. Our results show that there is little data of child growth monitoring, illustrated in Figures 5 and 6, and therefore implies the need for better practice in child growth monitoring.

Finally, post-hoc test were performed to verify the statistical models used. The majority of the test performed confirmed our models being both specified correctly and having a good model fit.

Conclusion

This thesis highlights the importance of monitoring child growth to get a true impression of the nutritional development and status of children in KZN. The analysis shows the double burden of malnutrition is present in KZN on an individual, household and community level. Risk factors such as sex, birthweight, socioeconomic factors and HIV status illustrate how the nutrition status of children are affected by different factors in society.

Nutrition sensitive and specific interventions can be designed to improve the rate of both stunting and overweight among children and overweight among adults in KZN. Teaching of health workers and nurses on how to perform length measurements, and monitoring of child growth among HIV positive mothers who come to the clinic for their ART once a month are two examples of interventions. Furthermore, interventions on antenatal care and prenatal care regarding food advice for the mothers and feeding advice for the infants are some examples of interventions already suggested in the Global Nutrition report and in the WHO recommendations on antenatal care and in Ending Childhood obesity. The nutrition transition is ongoing in South Africa, making fast food, savoury snacks and sweets more and easy available to people. Healthy eating during pregnancy plays an important role in the birthweight outcome of a child and mothers in KZN should therefore avoid eating too much of these snacks. Moreover, breastfeeding can be a potential preventable factor of rapid weight gain among infants giving ground for a more steady growth development in both length and weight as rapid weight gain in infancy is a risk factor for the development of disease later in life and should be prevented.

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Appendices

Table of content

Appendix 1 – 24h recall infant feeding

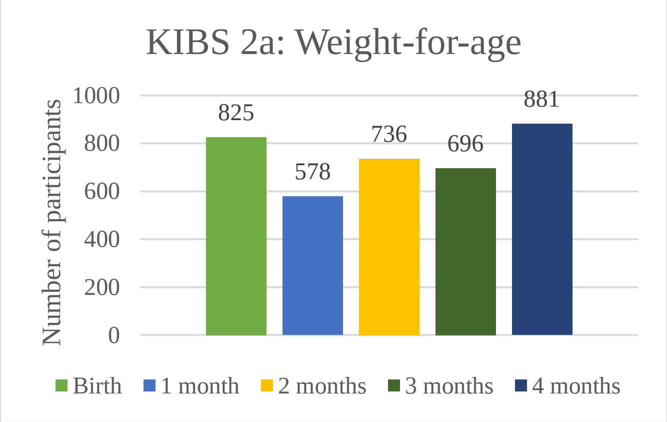
Table 19. All caregivers, both mothers and non-mothers respondents (n=1508). Categorized by calorie content, from low to high

	14 weeks		**6 months**		**Total**	
FLUIDS	n	%	n	%	n	%
Number of respondents	845		663		1508	
Water	133	14.3	305	78.2	438	25.7
Clear soup	1	0.1	34	4.4	35	2.1
Juice/tea	6	0.6	47	6.1	53	3.1
Other drinks	21	2.3	28	3.6	49	2.9
Other milks	1	0.1	5	0.6	6	0.4
Infant formula	302	32.5	292	37.7	594	34.9
Yoghurt/amasi	74	8.0	320	41.4	394	23.2
Vitamins	172	18.5	167	21.6	339	19.9
Traditional medicines	71	7.7	70	9.1	141	8.3
SOLIDS						
Any solids	70	7.5	297	38.4	367	21.6
Fruit/vegetables	5	0.5	31	4.0	36	2.1
Meat	1	0.1	26	3.4	27	1.6
Egg	1	0.1	50	6.5	51	3.0
Fish	1	0.1	5	0.6	6	0.4
Bread/rice/porridge	32	3.4	187	24.2	219	12.9
Cereal	82	8.8	254	32.9	36	19.8
Cheese	2	0.2	25	3.2	27	1.6
Sugar/sweets	2	0.2	38	4.9	40	2.4

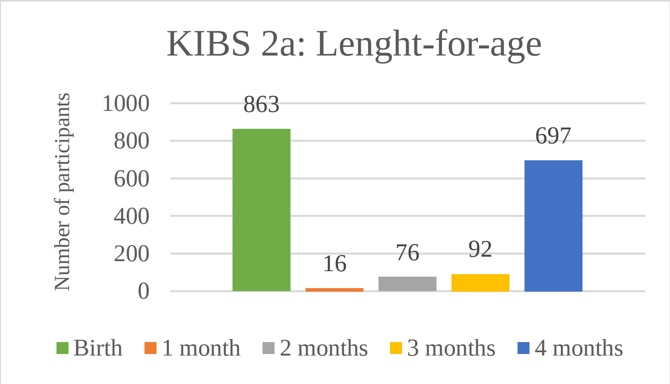
Appendix 2 – Illustrations

KIBS 2a: Distribution of weight and length at the different ages

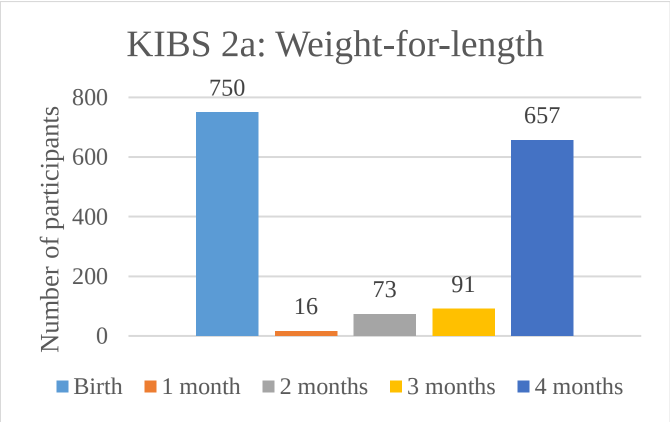
KIBS 2a: Weight-for-age. WAZ.



KIBS 2a: Length-for-age. LAZ.

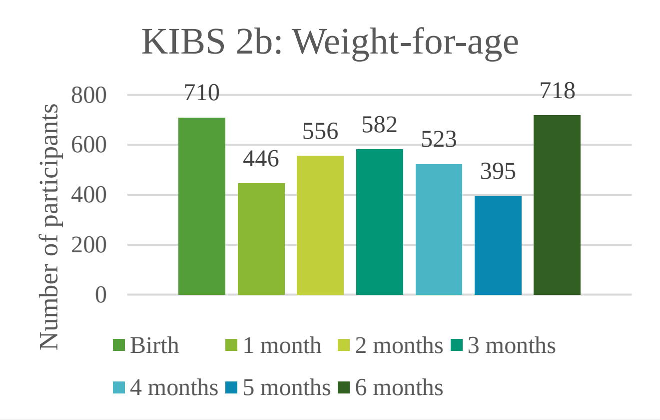


KIBS 2a: Weight-for-length. WLZ.

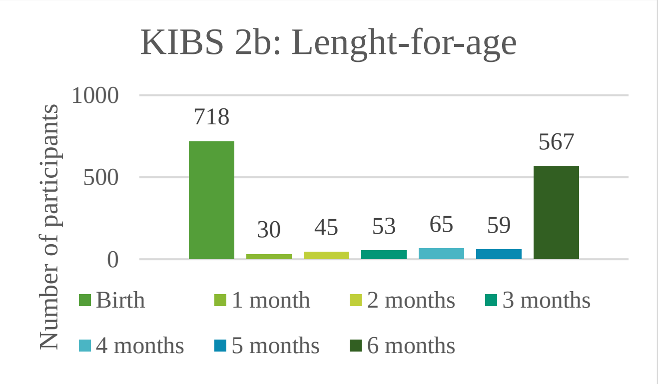


KIBS 2b: Distribution of weight and length at the different ages

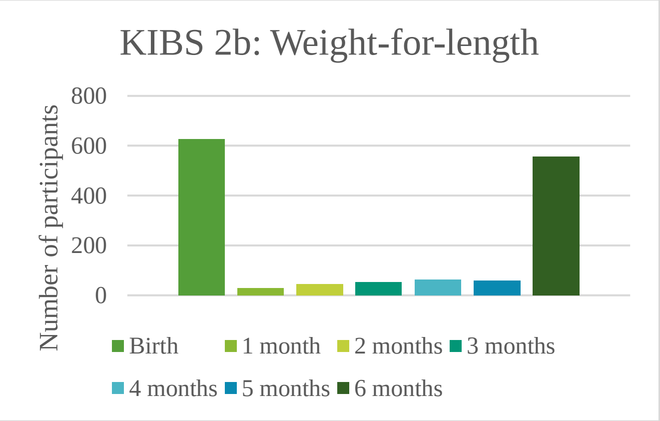
KIBS 2b: Weight-for-age. WAZ.



KIBS 2b: Length-for-age. LAZ.

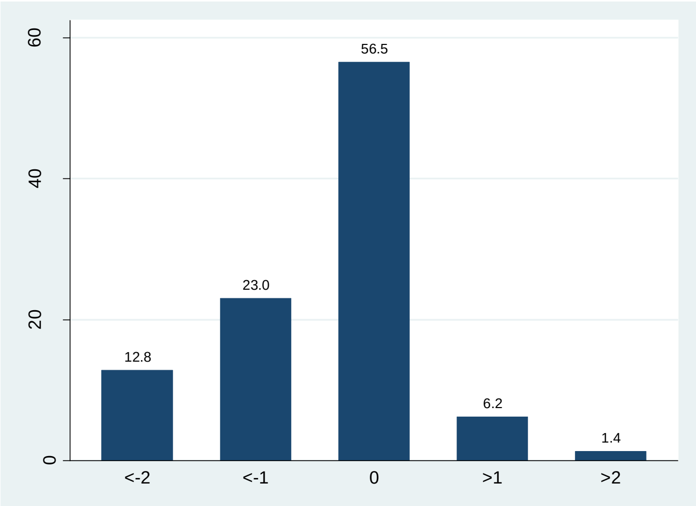


KIBS 2b: Weight-for-length. WLZ.

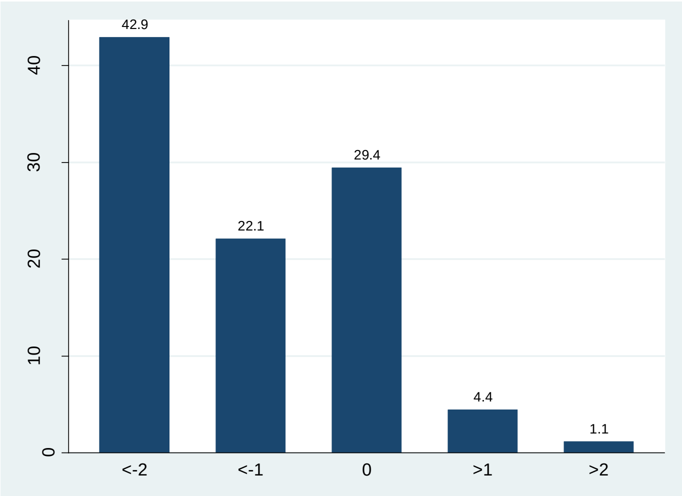


KIBS 2a: Distribution of z-score values

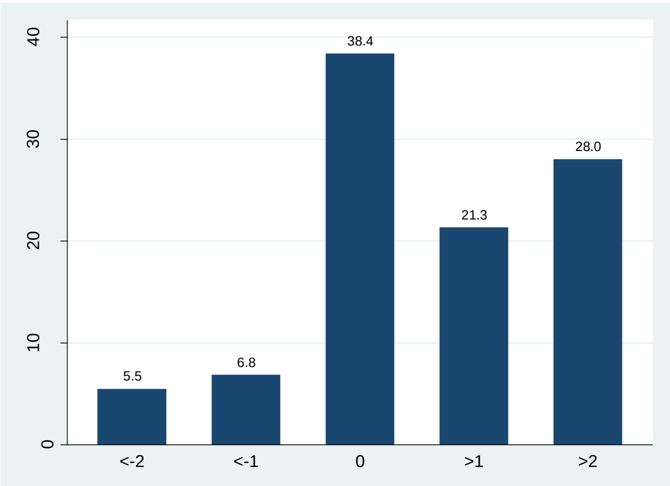
KIBS 2a: Weight-for-age



KIBS 2a: Length-for-age

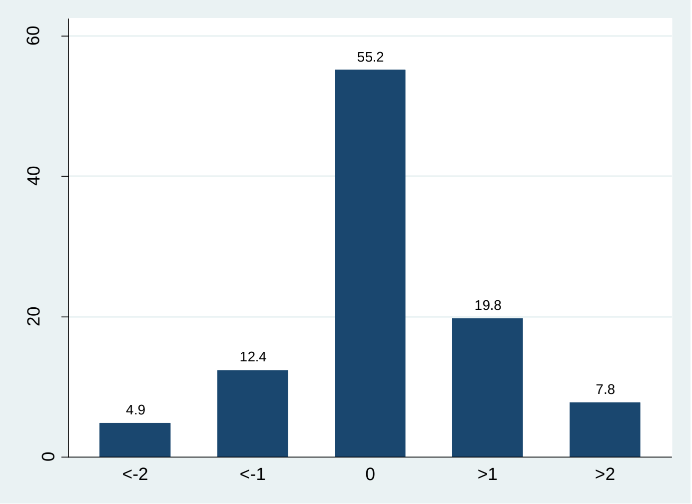


KIBS 2a: Weight-for-length

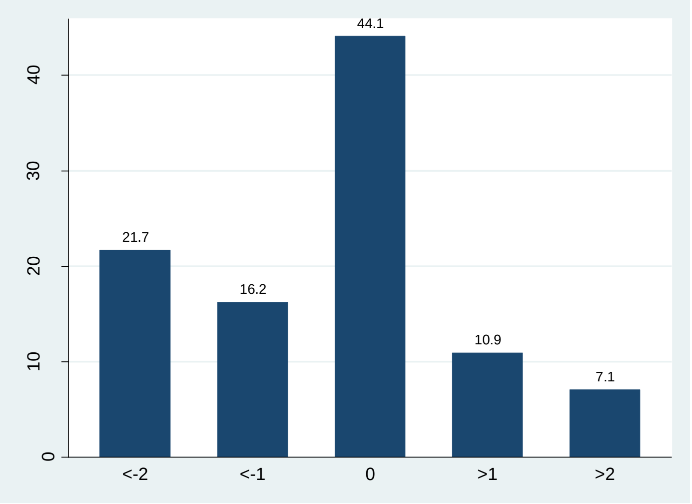


KIBS 2b: Distribution of z-score values

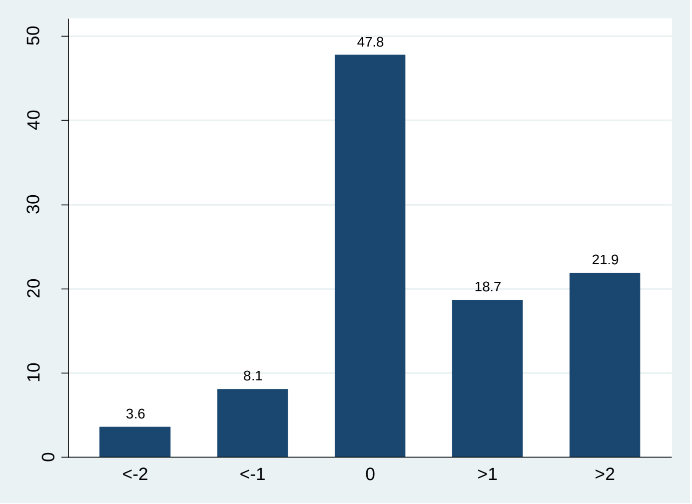
KIBS 2b: Weight-for-age



KIBS 2b: Length-for-age



KIBS 2b: Weight-for-length



Appendix 3 – Risk factor analysis. Crude and adjusted regression models

KIBS 2a: Linear regression. Weight-for-age

Crude linear regression table

Weight-for-age			**Crude WAZ**	
n total: 881	n	%	β	95% CI
Inherent factors				
Sex				
Boy	445	50.5		
Girl	436	49.5	0.19	-0.02; 0.40
Age (days)			**0.03**	**0.01; 0.05**
Immediate factors				
Breastfeeding				
Never	51	5.8		
Stopped	131	14.9	-0.38	-0.89; 0.13
Still	569	64.6	-0.13	-0.59; 0.32
Complementary feeding				
Formula ever given				
No	502	57.0		
Yes	244	27.7	-0.21	-0.42; 0.00
Intermediate factors				
Birthweight (kg)			**1.40**	**1.23; 1.58**
HIV exposure				
Mother HIV Negative	452	55.7		
Mother HIV Positive	287	35.4	**-0.25**	**-0.46; -0.02**
Breastfeeding after delivery				
Within 1 hour	330	40.7		
After 1 hour	364	44.9	-0.07	-0.34; 0.20
Distal factors				
Maternal and family factors				
Sibling				
No	329	40.6		
Yes	418	51.5	0.17	-0.04; 0.39

Mother's age			0.01	-0.00; 0.02
Mother's BMI			0.02	-0.00; 0.04
Mother's highest school grade				
0-7	50	6.2		
8-12	697	85.9	**0.38**	**0.01; 0.76**
Returned to school after birth				
No	298	36.7		
Yes	35	4.3	-0.43	-0.99; 0.13
Returned to work after birth				
No	685	84.5		
Yes	62	7.6	0.18	-0.20; 0.56
Socio-economic factors				
Household information				
Water - public	306	37.7		
Water - private	566	69.8	0.09	-0.09; 0.27
Toilet - pit	544	67.1		
Toilet - flush	328	40.4	0.08	-0.07; 0.23
Electricity in house				
No	88	10.9		
Yes	783	96.5	0.09	-0.27; 0.45
Cooking - other	175	21.6		
Cooking - electricity	696	85.8	0.04	-0.27; 0.36
Child support grant (R350.00)				
No	65	8.0		
Yes	675	83.2	0.14	-0.20; 0.49

Underlying factors				
Urban/rural status				
Urban	553	62.8		
Rural	328	37.2	0.12	-0.11; 0.35

Adjusted linear regression table

	Stage 1		Stage 2		Stage 3		Stage 4		Stage 5	
	β	95% CI	β	95% CI	β	95% CI	β	95% CI	β	95% CI
Sex - girl	0.19	-0.02; 0.41	0.14	-0.09; 0.36	**0.27**	**0.13; 0.40**	**0.25**	**0.02; 0.47**	**0.26**	**0.12; 0.40**
Age (days)	**0.03**	**0.01; 0.05**	**0.02**	**0.00; 0.04**	**0.03**	**0.01; 0.05**	0.01	-0.01; 0.04	**0.03**	**0.01; 0.05**
Birthweight, kg					**1.50**	**1.31; 1.69**	**1.29**	**0.92; 1.66**	**1.45**	**1.26; 1.64**
HIV positive mother					**-0.32**	**-0.51; -0.13**	**-0.48**	**-0.75; -0.21**	**-0.29**	**-0.46; -0.11**

KIBS 2a: Logistic regression. Weight-for-age <-2

Crude logistic regression table

Weight-for-age			**Underweight**	**Not underweight**	**Crude WAZ**	
n total: 881	n	%	n (%)	n (%)	OR	95% CI
Inherent factors						
Sex						
Boy	445	50.5	73 (16.3%)	376 (83.7%)		
Girl	436	49.5	44 (10.1%)	392 (89.9%)	0.61	0.36; 1.04
Age (days)					0.96	0.91; 1.01
Immediate factors						
Breastfeeding						
Never	51	5.8	7(13.7%)	44 (86.3%)		
Stopped	131	14.9	25 (19.1%)	106 (80.9%)	1.48	0.50; 4.42
Still	569	64.6	69 (12.1%)	500 (87.9%)	0.87	0.31; 2.39
Complementary feeding						
Formula ever given						
No	502	57.0	57 (11.3%)	445 (88.7%)		
Yes	244	27.7	43 (17.6%)	201 (82.4%)	**1.67**	**1.11; 2.51**
Intermediate factors						
Birthweight (kg)					**0.06**	**0.03; 0.10**
HIV exposure						
Mother HIV Negative	452	55.7	51 (11.3%)	401 (88.7%)		
Mother HIV Positive	287	35.4	49 (17.1%)	238 (82.9%)	**1.62**	**1.08; 2.42**
Breastfeeding after delivery						
Within 1 hour	330	40.7	37 (11.2%)	293 (88.8%)		
After 1 hour	364	44.9	56 (15.4%)	308 (84.6%)	1.44	0.81; 2.56
Distal factors						

Maternal and family factors						
Sibling						
No	329	40.6	45 (13.7%)	284 (86.3%)		
Yes	418	51.5	55 (13.2%)	363 (86.8%)	0.96	0.58; 1.58
Mother's age					0.97	0.94; 1.01
Mother's BMI					0.96	0.92; 1.01
Mother's highest school grade						
0-7	50	6.2	14 (28.0%)	36 (72.0%)		
8-12	697	85.9	86 (12.3%)	611 (86.7%)	0.28	0.05; 1.50
Returned to school after birth						
No	298	36.7	44 (14.8%)	254 (85.2%)		
Yes	35	4.3	9 (25.7%)	26 (74.3%)	2.0	0.92; 4.32
Returned to work after birth						
No	685	84.5	94 (13.7%)	591 (86.3%)		
Yes	62	7.6	6 (9.7%)	56 (90.3%)	0.67	0.31; 1.46
Socio-economic factors						
Household information						
Water - public	306	37.7	47 (15.4%)	259 (84.6%)		
Water - private	566	69.8	65 (11.5%)	501 (88.5%)	0.71	0.46; 1.11
Toilet - pit	544	67.1	75 (13.8%)	469 (86.2%)		
Toilet - flush	328	40.4	37 (11.3%)	291 (88.7%)	0.79	0.47; 1.33
Electricity in house						
No	88	10.9	17 (19.3%)	71 (80.7%)		
Yes	783	96.5	95 (12.1%)	688 (87.9%)	0.58	0.23; 1.47

Cooking - other	175	21.6	29 (16.6%)	146 (83.4%)		
Cooking - electricity	696	85.8	83 (11.9%)	613 (88.1%)	0.68	0.33; 1.39
Child support grant (R350.00)						
No	65	8.0	10 (15.2%)	55 (84.6%)		
Yes	675	83.2	89 (13.2%)	586 (86.8%)	0.83	0.43; 1.63
Underlying factors						
Urban/rural status						
Urban	553	62.8	83 (15.0%)	470 (85.0%)		
Rural	328	37.2	30 (9.2%)	298 (90.8%)	**0.57**	**0.35; 0.93**

Adjusted logistic regression

	Stage 1		Stage 2		Stage 3		Stage 4		Stage 5	
	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI
Sex – female	0.61	0.35; 1.04	0.73	0.43; 1.25	**0.52**	**0.31; 0.87**	0.68	0.23; 1.98	**0.55**	**0.33; 0.91**
Age (days)	0.96	0.91; 1.01	0.97	0.92; 1.03	0.96	0.90; 1.03	0.96	0.87; 1.06	0.95	0.89; 1.03
Birthweight, kg					**0.04**	**0.02; 0.08**	**0.06**	**0.02; 0.23**	**0.05**	**0.03; 0.10**
HIV positive mother					**2.03**	**1.15; 3.61**	**2.52**	**1.09; 5.86**	**1.97**	**1.20; 3.24**

KIBS 2b: Linear regression. Weight-for-age

Crude linear regression table

Weight-for-age.			**Crude WAZ**	
n total: 718	n	%	β	95% CI
Inherent factors				
Sex				
Boy	360	50.1		
Girl	358	49.9	0.20	-0.01; 0.41
Age (days)			0.01	-0.00; 0.02
Immediate factors				
Breastfeeding				
Never	37	5.2		
Stopped	127	17.7	0.06	-0.44; 0.56
Still	400	55.7	-0.15	-0.58; 0.28
Complementary feeding				
Formula ever given				
No	327	45.5		
Yes	236	32.9	0.18	-0.02; 0.39
Intermediate factors				
Birthweight (kg)			**1.11**	**0.95; 1.28**
HIV exposure				
Mother HIV Negative	337	46.9		
Mother HIV Positive	217	30.2	**-0.33**	**-0.53; -0.14**
Breastfeeding after delivery				
Within 1 hour	268	37.3		
After 1 hour	248	34.5	-0.00	-0.26; 0.25
Distal factors				
Maternal and family factors				
Sibling				
No	223	31.1		
Yes	340	47.4	-0.12	-0.38; 0.13
Mother's age			-0.00	-0.01; 0.01

Mother's BMI			**0.02**	**0.00; 0.04**
Mother's highest school grade				
0-7	38	5.3		
8-12	525	73.1	0.03	-0.61; 0.67
Returned to school after birth				
No	233	32.5		
Yes	39	5.4	0.24	-0.15; 0.65
Returned to work after birth				
No	484	67.4		
Yes	79	11.0	**0.39**	**0.08; 0.71**
Socio-economic factors				
Household information				
Water - public	307	42.8		
Water - private	400	55.7	0.05	-0.16; 0.27
Toilet - pit	492	68.5		
Toilet - flush	215	29.9	0.23	-0.07; 0.52
Electricity in house				
No	104	14.5		
Yes	603	84.0	0.00	-0.26; 0.26
Cooking - other	195	27.2		
Cooking - electricity	511	71.2	0.18	-0.05; 0.42
Child support grant (R350.00)				
No	55	7.7		
Yes	501	69.8	-0.14	-0.53; 0.26
Underlying factors				
Urban/rural status				
Urban	533	74.2		
Rural	185	25.8	0.26	-0.02; 0.55

Adjusted linear regression

Adjusted WAZ	**Stage 1**		**Stage 2**		**Stage 3**		**Stage 4**		**Stage 5**	
	β	95% CI	β	95% CI	β	95% CI	β	95% CI	β	95% CI
Sex – female	0.20	-0.01; 0.41	0.20	-0.08; 0.47	**0.36**	**0.16; 0.56**	**0.40**	**0.08; 0.71**	**0.32**	**0.14; 0.50**
Age (days)	0.01	-0.00; 0.02	**0.01**	**0.00; 0.02**	**0.01**	**0.00; 0.02**	0.00	-0.01; 0.02	**0.01**	**0.00; 0.02**
Birthweight, kg					**1.15**	**0.98; 1.33**	**1.17**	**0.86; 1.48**	**1.15**	**0.97; 1.33**
HIV positive mother					**-0.26**	**-0.47; -0.06**				

KIBS 2b: Logistic regression. Weight-for-age <-2

Crude logistic regression table

Weight-for-age.			**Underweight**	**Not underweight**	**Crude WAZ**	
n total: 718	n	%	n (%)	n (%)	OR	95% CI
Inherent factors						
Sex						
Boy	360	50.1	23 (6.4%)	337 (93.6%)		
Girl	358	49.9	12 (3.4%)	346 (96.6%)	0.51	0.23; 1.14
Age (days)					0.99	0.94; 1.04
Immediate factors						
Breastfeeding						
Never	37	5.2	0	37 (100%)		
Stopped	127	17.7	7 (5.5%)	120 (94.5%)		
Still	400	55.7	20 (5.0%)	380 (95.0%)	0.90	0.37; 2.18
Complementary feeding						
Formula given		45.5				
No	327	32.9	17 (5.2%)	310 (94.8%)		
Yes	236		10 (4.2%)	226 (95.8%)	0.81	0.34; 1.90
Intermediate factors						
Birthweight (kg)					**0.13**	**0.07; 0.26**
HIV exposure						
Mother HIV Negative	337	46.9	9 (2.7%)	328 (97.3%)		
Mother HIV Positive	217	30.2	17 (7.8%)	200 (92.2%)	**3.10**	**1.27; 7.57**
Breastfeeding after delivery						
Within 1 hour	268	37.3	14 (5.2%)	254 (94.8%)		
After 1 hour	248	34.5	12 (4.8%)	236 (95.2%)	0.92	0.46; 1.86
Distal factors						
Maternal and family factors						

Sibling						
No	223	31.1	7 (3.1%)	216 (96.9%)		
Yes	340	47.4	20 (5.9%)	320 (94.1%)	1.93	0.72; 5.14
Mother's age		5.3			1.00	0.97; 1.04
Mother's BMI		73.1			0.99	0.94; 1.05
Mother's highest school grade						
0-7	38	32.5	1 (2.6%)	37 (97.4%)		
8-12	525	5.4	26 (4.9%)	499 (95.1%)	1.93	0.20; 18.25
Returned to school after birth						
No	233	67.4	18 (7.7%)	215 (92.3%)		
Yes	39	11.0	0	39 (100%)	**omitted**	
Returned to work after birth						
No	484	42.8	24 (5.0%)	460 (95.0%)		
Yes	79	55.7	3 (3.8%)	76 (96.2%)	0.76	0.15; 3.68
Socio-economic factors						
Household information						
Water - public	307	68.5	12 (3.9%)	295 (96.1%)		
Water - private	400	29.9	23 (5.7%)	377 (94.3%)	1.50	0.70; 3.20
Toilet - pit	492	14.5	26 (5.3%)	466 (94.7%)		
Toilet - flush	215	84.0	9 (4.2%)	206 (95.8%)	0.78	0.36; 1.72
Electricity in house						
No	104	27.2	5 (4.8%)	99 (95.2%)		
Yes	603	71.2	30 (5.0%)	573 (95.0%)	1.04	0.46; 2.36
Cooking - other	195	7.7	14 (7.2%)	181 (92.8%)		

Cooking - electricity	511	69.8	21 (4.1%)	490 (95.9%)	0.55	0.29; 1.06
Child support grant (R350.00)						
No	55	74.2	3 (5.5%)	52 (94.5%)		
Yes	501	25.8	23 (4.6%)	478 (95.4%)	0.83	0.25; 2.81
Underlying factors						
Urban/rural status						
Urban	533	50.1	29 (5.4%)	504 (94.6%)		
Rural	185	49.9	6 (3.2%)	179 (96.8%)	0.58	0.19; 1.81

Adjusted logistic regression

Adjusted WAZ	**Stage 1**		**Stage 2**		**Stage 3**		**Stage 4**		**Stage 5**	
	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI
Sex – female	0.51	0.22; 1.14	0.41	0.15; 1.12	0.16	0.04; 0.61	**0.07**	**0.01; 0.53**	**0.21**	**0.08; 0.53**
Age (days)	0.99	0.95; 1.04	0.98	0.93; 1.03	0.98	0.93; 1.04	**0.92**	**0.87; 0.97**		
Birthweight, kg					**0.09**	**0.04; 0.20**	**0.01**	**0.00; 0.40**	**0.09**	**0.04; 0.20**
HIV positive mother					**4.94**	**1.66; 14.67**				
Water - private							**52.88**	**11.05; 253.05**	**4.11**	**1.60; 10.58**
Electricity in house - yes							**3.27**	**1.10; 9.72**		
Cooking – electricity							**0.04**	**0.00; 0.35**	**0.20**	**0.08; 0.50**

KIBS 2a: Linear regression table. Length-for-age

Crude linear regression

Length-for-age			**Crude LAZ**	
n total: 697	n	%	β	95% CI
Inherent factors				
Sex				
Boy	352	50.5		
Girl	345	49.5	**0.42**	**0.11; 0.73**
Age (days)			-0.01	-0.40; 0.03
Immediate factors				
Breastfeeding				
Never	40	5.7		
Stopped	104	14.9	-0.48	-1.19; 0.23
Still	449	64.4	-0.51	-1.10; 0.08
Complementary feeding				
Formula ever given				
No	398	57.1		
Yes	191	27.4	0.19	-0.18; 0.53
Intermediate factors				
Birthweight (kg)			**0.92**	**0.61; 1.24**
HIV exposure				
Mother HIV Negative	359	51.5		
Mother HIV Positive	224	32.1	-0.40	-0.78; 0.25
Breastfeeding after delivery				
Within 1 hour	265	38.0		
After 1 hour	286	41.0	-0.38	-0.77; 0.01
Distal factors				
Maternal and family factors				
Sibling				
No	265	38.0		
Yes	325	46.6	0.22	-0.04; 0.48

Mother's age			0.00	-0.02; 0.02
Mother's BMI			-0.01	-0.05; 0.02
Mother’s highest school grade				
0-7	36	5.2		
8-12	554	79,5	-0.24	-0.76; 0.27
Returned to school after birth				
No	231	33.1		
Yes	30	4.3	-0.61	-1.40; 0.18
Returned to work after birth				
No	546	78.3		
Yes	44	6.3	0.25	-0.30; 0.81
Socio-economic factors				
Household information				
Water - public	251	44.3		
Water - private	306	54.0	-0.14	-0.72; 0.43
Toilet - pit	395	69.7		
Toilet - flush	162	28.6	0.10	-0.54; 0.74
Electricity in house				
No	90	15.9		
Yes	467	82.4	0.03	-0.64; 0.69
Cooking - other	163	28.7		
Cooking - electricity	393	69.3	0.10	-0.41; 0.61
Child support grant (R350.00)				
No	41	7.2		
Yes	394	69.5	-0.58	-1.19; 0.02
Underlying factors				

Urban/rural status				
Urban	437	62.7		
Rural	260	37.3	-0.36	-1.16; 0.44

KIBS 2a: Logistic regression table. Length-for-age <-2.

Crude logistic regression

Length-for-age			**Stunted**	**Not stunted**	**Crude LAZ**	
n total: 697	n	%	n (%)	n (%)	OR	95% CI
Inherent factors						
Sex						
Boy	352	50.5	173 (49.1%)	179 (50.9%)		
Girl	345	49.5	126 (36.5%)	219 (63.5%)	**0.59**	**0.41; 0.87**
Age (days)					1.01	0.97; 1.04
Immediate factors						
Breastfeeding						
Never	40	5.7	15 (37.5%)	25 (37.5%)		
Stopped	104	14.9	48 (46.1%)	56 (53.9%)	1.43	0.62; 3.28
Still	449	64.4	188 (41.9%)	261 (58.1%)	1.20	0.53; 2.73
Complementary feeding						
Formula ever given						
No	398	57.1	173 (43.5%)	225 (56.5%)		
Yes	191	27.4	76 (39.8%)	115 (60.2%)	0.86	0.58; 1.28
Intermediate factors						
Birthweight (kg)					**0.38**	**0.24; 0.60**
HIV exposure						
Mother HIV Negative	359	51.5	133 (37.0%)	226 (63.0%)		
Mother HIV Positive	224	32.1	113 (50.5%)	111 (49.5%)	**1.73**	**1.69; 2.56**
Breastfeeding after delivery						
Within 1 hour	265	38.0	99 (37.4%)	166 (62.6%)		
After 1 hour	286	41.0	139 (48.6%)	147 (51.4%)	**1.58**	**1.01; 2.48**
Distal factors						
Maternal and family factors						
Sibling						
No	265	38.0	113 (42.6%)	152 (57.4%)		

Yes	325	46.6	136 (41.8%)	189 (58.2%)	0.97	0.73; 1.28
Mother's age					1.01	0.99; 1.02
Mother's BMI					1.01	0.97; 1.04
Mother’s highest school grade						
0-7	36	5.2	16 (44.4%)	20 (55.6%)		
8-12	554	79.5	233 (42.1%)	321 (57.9%)	0.91	0.48; 1.72
Returned to school after birth						
No	231	33.1	92 (39.8%)	139 (60.2%)		
Yes	30	4.3	15 (50.0%)	15 (50.0%)	1.51	0.63; 3.59
Returned to work after birth						
No	546	78.3	228 (41.8%)	318 (58.2%)		
Yes	44	6.3	21 (47.7%)	23 (52.3%)	1.27	0.60; 2.69
Socio-economic factors						
Household information						
Water - public	246	35.3	82 (33.3%)	164 (66.7%)		
Water - private	442	63.4	213 (48.2%)	229 (51.8%)	1.86	0.98; 3.51
Toilet - pit	426	61.1	176 (41.3%)	250 (58.7%)		
Toilet - flush	262	37.6	119 (45.4%)	143 (54.6%)	1.18	0.66; 2.11
Electricity in house						
No	69	9.9	21 (30.4%)	48 (69.6%)		
Yes	619	88.8	274 (44.3%)	345 (55.7%)	1.81	0.83; 3.97
Cooking - other	136	19.5	40 (29.4%)	96 (70.6%)		
Cooking - electricity	552	79.2	255 (46.2%)	297 (53.8)	**2.06**	**1.23; 3.45**
Child support grant (R350.00)						
No	48	6.9	19 (39.6%)	228 (42.4%)		

Yes	538	77.2	29 (60.4%)	310 (57.6%)	1.12	0.60; 2.11
Underlying factors						
Urban/rural status						
Urban	437	62.7	168(38.4%)	269 (61.6%)		
Rural	260	37.3	131 (50.4%)	129 (49.6%)	1.63	0.71; 3.73

KIBS 2b: Linear regression table. Length-for-age

Crude linear regression

Length-for-age.			**Crude LAZ**	
n total: 567	n	%	β	95% CI
Inherent factors				
Sex				
Boy	284	50.1		
Girl	283	49.9	**0.46**	**0.11; 0.81**
Age (days)			-0.00	-0.02; 0.01
Intermediate factors				
Breastfeeding				
Never	26	4.6		
Stopped	84	14.8	0.12	-0.43; 0.67
Still	332	58.6	-0.40	-0.94; 0.14
Complementary feeding				
Formula ever given				
No	271	47.8		
Yes	170	30.0	**0.46**	**0.13; 0.79**
Intermediate factors				
Birthweight (kg)			0.78	0.45; 1.11
HIV exposure				
Mother HIV Negative	269	47.4		
Mother HIV Positive	167	29.5	-0.29	-0.66; 0.08
Breastfeeding after delivery				
Within 1 hour	217	38.3		
After 1 hour	192	33.9	-0.28	-0.67; 0.10
Distal factors				
Maternal and family factors				
Sibling				
No	170	30.0		
Yes	271	47.8	-0.05	-0.47; 0.37
Mother's age			0.01	-0.01; 0.02
Mother's BMI			-0.00	-0.03; 0.02

Mother's highest school grade				
0-7	31	5.5		
8-12	410	72.3	0.27	-0.44; 0.98
Returned to school after birth				
No	178	31.4		
Yes	26	4.6	0.29	-0.32; 0.91
Returned to work after birth				
No	390	68.8		
Yes	51	9.0	0.28	-0.23; 0.79
Socio-economic factors				
Household information				
Water - public	251	44.3		
Water - private	306	54.0	-0.14	-0.72; 0.43
Toilet - pit	395	69.7		
Toilet - flush	162	28.6	0.10	-0.54; 0.74
Electricity in house				
No	90	15.9		
Yes	467	82.4	0.03	-0.64; 0.69
Cooking - other	163	28.7		
Cooking - electricity	393	69.3	0.10	-0.41; 0.61
Child support grant (R350.00)				
No	41	7.2		
Yes	394	69.5	-0.58	-1.19; 0.02
Underlying factors				
Urban/rural status				
Urban	425	75.0		
Rural	142	25.0	0.21	-0.61; 1.02

KIBS 2b: Logistic regression table. Length-for-age <-2

Crude linear regression

Length-for-age			**Stunted**	**Not stunted**	**Crude LAZ**	
n total: 567	n	%	n (%)	n (%)	OR	95% CI
Inherent factors						
Sex						
Boy	284	50.1	70 (24.6%)	214 (75.4%)		
Girl	283	49.9	53 (18.7%)	230 (81.3%)	0.70	0.44; 1.12
Age (days)					1.00	0.98; 1.02
Immediate factors						
Breastfeeding						
Never	26	4.6	3 (11.5%)	23 (88.5%)		
Stopped	84	14.8	16 (19.1%)	68 (80.9%)	1.80	0.61; 5.31
Still	332	58.6	74 (22.3%)	258 (77.7%)	2.20	0.60; 8.04
Complementary feeding						
Formula ever given						
No	271	47.8	64 (23.6%)	207 (76.4%)		
Yes	170	30.0	29 (17.1%)	141 (82.9%)	0.66	0.39; 1.13
Intermediate factors						
Birthweight (kg)					**0.35**	**0.20; 0.63**
HIV exposure						
Mother HIV Negative	269	47.4	55 (20.5%)	214 (79.5%)		
Mother HIV Positive	167	29.5	38 (22.7%)	129 (77.3%)	1.15	0.70; 1.87
Breastfeeding after delivery						
Within 1 hour	217	38.3	41 (18.9%)	176 (81.1%)		
After 1 hour	192	33.9	50 (26.0%)	142 (74.0%)	1.51	0.87; 2.63
Distal factors						
Maternal and family factors						
Sibling						
No	170	30.0	38 (22.3%)	132 (77.7%)		

Yes	271	47.8	55 (20.3%)	216 (79.7%)	0.88	0.50; 1.55
Mother's age					0,99	0.96; 1.01
Mother's BMI					1.02	0.98; 1.06
Mother's highest school grade						
0-7	31	5.5	5 (16.1%)	26 (83.9%)		
8-12	410	72.3	88 (21.5%)	322 (78.5%)	1.42	0.57; 3.56
Returned to school after birth						
No	178	31.4	43 (24.2%)	135 (75.8%)		
Yes	26	4.6	4 (15.4%)	22 (84.6%)	0.57	0.16; 2.0
Returned to work after birth						
No	390	68.8	84 (21.5%)	306 (78.5%)		
Yes	51	9.0	9 (17.6%)	42 (82.4%)	0.78	0.32; 1.90
Socio-economic factors						
Household information						
Water - public	251	44.3	46 (18.3%)	205 (81.7%)		
Water - private	306	54.0	76 (24.8%)	230 (75.2%)	1.47	0.85; 2.56
Toilet - pit	395	69.7	84 (21.3%)	311 (78.7%)		
Toilet - flush	162	28.6	38 (23.5%)	124 (76.5%)	1.13	0.59; 2.19
Electricity in house						
No	90	15.9	18 (20.0%)	72 (80.0%)		
Yes	467	82.4	104 (22.3%)	363 (77.7%)	1.15	0.66; 1.98
Cooking - other	163	28.7	33 (20.2%)	130 (79.8%)		
Cooking - electricity	393	69.3	89 (22.6%)	304 (77.4%)	1.15	0.73; 1.82
Child support grant (R350.00)						
No	41	7.2	5 (12.2%)	36 (87.8%)		

Yes	394	69.5	86 (21.8%)	308 (78.2%)	2.01	0.83; 4.88
Underlying factors						
Urban/rural status						
Urban	425	75.0	94 (22.1%)	331 (77.9%)		
Rural	142	25.0	29 (20.4%)	113 (79.6%)	0.90	0.38; 2.14

KIBS 2a: Linear regression table. Weight-for-length

Crude linear regression

Weight-for-length			**Crude WLZ**	
n total: 657	n	%	β	95% CI
Inherent factors				
Sex				
Boy	330	50.2		
Girl	327	49.8	-0.09	-0.34; 0.16
Age (days)			0.02	-0.01; 0.06
Immediate factors				
Breastfeeding				
Never	39	5.9		
Stopped	97	14.8	-0.30	-0.99; 0.39
Still	425	64.7	0.14	-0.41; 0.68
Complementary feeding				
Formula ever given				
No	375	57.1		
Yes	182	27.7	**-0.45**	**-0.85; -0.05**
Intermediate factors				
Birthweight (kg)			**0.41**	**0.09; 0.73**
HIV exposure				
Mother HIV Negative	337	51.3		
Mother HIV Positive	214	32.6	0.16	-0.19; 0.52
Breastfeeding after delivery				
Within 1 hour	258	39.3		
After 1 hour	262	39.9	0.04	-0.45; 0.53
Distal factors				
Maternal and family factors				
Sibling				
No	249	37.9		
Yes	309	47.0	-0.06	-0.31; 0.18
Mother's age			0.00	-0.02; 0.02
Mother's BMI			0.02	-0.07; 0.05

Mother's highest school grade				
0-7	36	5.5		
8-12	522	79.5	0.28	-0.26; 0.82
Returned to school after birth				
No	223	33.9		
Yes	27	4.1	-0.22	-1.32; 0.89
Returned to work after birth				
No	515	78.4		
Yes	43	6.5	0.28	-0.49; 1.05
Socio-economic factors				
Household information				
Water - public	245	37.3		
Water - private	405	61.6	0.36	-0.26; 0.98
Toilet - pit	410	62.4		
Toilet - flush	240	36.5	0.06	-0.48; 0.61
Electricity in house				
No	70	10.7		
Yes	580	88.3	0.05	-0.35; 0.46
Cooking - other	136	20.7		
Cooking - electricity	514	78.2	0.11	-0.30; 0.52
Child support grant (R350.00)				
No	48	7.3		
Yes	507	77.2	0.07	-0.45; 0.59
Underlying factors				
Urban/rural status				
Urban	420	63.9		
Rural	237	36.1	0.33	-0.45; 1.11

KIBS 2a: Logistic regression table. Weight-for-length <-2.

Crude linear regression

Weight-for-length			**Wasted**	**Not wasted**	**Crude WLZ**	
n total: 657	n	%	n (%)	n (%)	OR	95% CI
Inherent factors						
Sex						
Boy	330	50.2	21 (6,4%)	309 (93,6%)		
Girl	327	49.8	15 (4,6%)	312 (95,4%)	0.71	0.36; 1.39
Age (days)					1.00	0.90; 1.10
Immediate factors						
Breastfeeding						
Never	39	5.9	2 (5.1%)	37 (94.9%)		
Stopped	97	14.8	9 (9.3%)	88 (90.7%)	1.89	0.35; 10.22
Still	425	64.7	17 (4.0%)	408 (96.0%)	0.77	0.13; 4.43
Complementary feeding						
Formula given						
No	375	57.1	13 (3.5%)	362 (96.5%)		
Yes	182	27.7	15 (8.2%)	167 (91.8%)	2.50	0.94; 6.65
Intermediate factors						
Birthweight (kg)					0.53	0.26; 1.10
HIV exposure						
Mother HIV Negative	337	51.3	19 (5.6%)	318 (94.4%)		
Mother HIV Positive	214	32.6	9 (4.2%)	205 (95.8%)	0.73	0.26; 2.04
Breastfeeding after delivery						
Within 1 hour	258	39.3	12 (4.6%)	246 (95.4%)		
After 1 hour	262	39.9	13 (5.0%)	249 (95.0%)	1.07	0.40; 2.86
Distal factors						
Maternal and family factors						
Sibling						
No	249	37.9	10 (4.0%)	239 (96.0%)		
Yes	309	47.0	18 (5.8%)	291 (94.2%)	1.48	0.78; 2.79
Mother's age					1.01	0.96; 1.07

Mother's BMI					1.00	0.96; 1.05
Mother's highest school grade						
0-7	36	5.5	1 (2.7%)	35 (97.2%)		
8-12	522	79.5	27 (5.2%)	495 (94.8%)	1.91	0.18; 20.62
Returned to school after birth						
No	223	33.9	10 (4.5%)	213 (95.5%)		
Yes	27	4.1	3 (11.1%)	24 (88.9%)	2.66	0.60; 11.85
Returned to work after birth						
No	515	78.4	26 (5.0%)	489 (95.0%)		
Yes	43	6.5	2 (4.6%)	41 (95.3%)	0.92	0.18; 4.57
Socio-economic factors						
Household information						
Water - public	245	37.3	14 (5.7%)	231 (94.3%)		
Water - private	405	61.6	21 (5.2%)	384 (94.8%)	0.90	0.47; 1.74
Toilet - pit	410	62.4	25 (6.1%)	385 (93.9%)		
Toilet - flush	240	36.5	10 (4.2%)	230 (95.8%)	0.67	0.29; 1.54
Electricity in house						
No	70	10.7	1 (1.4%)	69 (98.6%)		
Yes	580	88.3	34 (5.9%)	546 (94.1%)	4.30	0.45; 41.04
Cooking - other	136	20.7	6 (4.4%)	130 (95.4%)		
Cooking - electricity	514	78.2	29 (5.6%)	485 (94.4%)	1.29	0.45; 3.73
Child support grant (R350.00)						
No	48	7.3	5 (10.4%)	43 (89.6%)		
Yes	507	77.2	23 (4.5%)	484 (95.5%)	0.41	0.18; 0.93
Underlying factors						
Urban/rural status						

Urban	420	63.9	25 (5.9%)	395 (94.1%)		
Rural	237	36.1	11 (4.6%)	226 (95.4%)	0.76	0.31; 1.92

KIBS 2b: Linear regression table. Weight-for-length

Crude logistic regression

Weight-for-length			**Crude WLZ**	
n total: 557	n	%	β	95% CI
Inherent factors				
Sex				
Boy	277	49.7		
Girl	280	50.3	-0.06	-0.38; 0.25
Age (days)			0.01	-0.01; 0.03
Immediate factors				
Breastfeeding				
Never	26	4.7		
Stopped	83	14.9	0.02	-0.64; 0.68
Still	325	58.3	-0.07	-0.75; 0.61
Complementary feeding				
Formula given				
No	264	47.4		
Yes	169	30.3	-0.03	-0.38; 0.33
Intermediate factors				
Birthweight (kg)			**0.57**	**0.31; 0.83**
HIV exposure				
Mother HIV Negative	265	47.6		
Mother HIV Positive	163	29.3	-0.07	-0.36; 0.21
Breastfeeding after delivery				
Within 1 hour	216	38.8		
After 1 hour	185	33.2	0.13	-0.28; 0.54
Distal factors				
Maternal and family factors				
Sibling				
No	167	30.0		
Yes	266	47.8	-0.08	-0.44; 0.28
Mother's age			-0.01	-0.02; 0.01

Mother's BMI			0.03	-0.00; 0.05
Mother's highest school grade				
0-7	31	5.6		
8-12	402	72.2	0.12	-0.49; 0.74
Returned to school after birth				
No	177	31.8		
Yes	26	4.7	-0.11	-0.68; 0.46
Returned to work after birth				
No	382	68.6		
Yes	51	9.2	0.20	-0.28; 0.68
Socio-economic factors				
Household information				
Water - public	248	44.5		
Water - private	299	53.7	0.16	-0.31; 0.64
Toilet - pit	389	69.8		
Toilet - flush	158	28.4	0.34	-0.15; 0.84
Electricity in house				
No	90	16.2		
Yes	457	82.0	0.06	-0.44; 0.55
Cooking - other	164	29.4		
Cooking - electricity	382	68.6	0.15	-0.27; 0.57
Child support grant (R350.00)				
No	40	7.2		
Yes	387	69.5	0.06	-0.47; 0.60
Underlying factors				
Urban/rural status				
Urban	418	75.0		
Rural	139	25.0	0.25	-0.37; 0.87

KIBS 2b: Logistic regression table. Weight-for-length <-2

Crude logistic regression

Weight-for-length**.**			**Wasted**	**Not wasted**	**Crude WLZ**	
n total: 557	n	%	n (%)	n (%)	OR	95% CI
Inherent factors						
Sex						
Boy	277	49.7	11 (4.0%)	266 (96.0%)		
Girl	280	50.3	9 (3.2%)	271 (96.8%)	0.80	0.28; 2.33
Age (days)					0.98	0.95; 1.02
Immediate factors						
Breastfeeding						
Never	26	4.7	1 (3.8%)	25 (96.2%)		
Stopped	83	14.9	4 (4.8%)	79 (95.2%)	1.26	0.20; 8.09
Still	325	58.3	13 (4.0%)	312 (96.0%)	1.04	0.14; 2.93
Complementary feeding						
Formula ever given						
No	264	47.4	11 (4.2%)	253 (95.8%)		
Yes	169	30.3	7 (4.1%)	162 (95.9%)	0.99	0.34; 2.93
Intermediate factors						
Birthweight (kg)					0.58	0.27; 1.25
HIV exposure						
Mother HIV Negative	265	47.6	8 (3.0%)	257 (97.0%)		
Mother HIV Positive	163	29.3	8 (4.9%)	155 (95.1%)	1.66	0.59; 4.69
Breastfeeding after delivery						
Within 1 hour	216	38.8	9 (4.2%)	207 (95.8%)		
After 1 hour	185	33.2	9 (4.9%)	176 (95.1%)	1.18	0.45; 3.09
Distal factors						
Maternal and family factors						
Sibling						
No	167	30.0	5 (3.0%)	162 (97.0%)		
Yes	266	47.8	13 (4.9%)	253 (95.1%)	1.66	0.54; 5.12

Mother's age					1.00	0.95; 1.05
Mother's BMI					0.99	0.92; 1.07
Mother's highest school grade						
0-7	31	5.6	1 (3.2%)	30 (96.8%)		
8-12	402	72.2	17 (4.2%)	385 (73.8%)	1.32	0.15; 11.46
Returned to school after birth						
No	177	31.8	7 (3.9%)	170 (96.1%)		
Yes	26	4.7	1 (3.9%)	25 (96.1%)	0.97	0.10; 9.46
Returned to work after birth						
No	382	68.6	15 (3.9%)	367 (96.1%)		
Yes	51	9.2	3 (5.9%)	48 (94.1%)	1.53	0.29; 8.05
Socio-economic factors						
Household information						
Water - public	248	44.5	8 (3.2%)	240 (96.8%)		
Water - private	299	53.7	12 (4.0%)	287 (96.0%)	1.25	0.52; 3.01
Toilet - pit	389	69.8	14 (3.6%)	375 (96.4%)		
Toilet - flush	158	28.4	6 (3.8%)	152 (96.2%)	1.06	0.35; 3.23
Electricity in house						
No	90	16.2	3 (3.3%)	87 (96.7%)		
Yes	457	82.0	17 (3.7%)	440 (96.3%)	1.12	0.40; 3.10
Cooking - other	164	29.4	5 (3.0%)	159 (97.0%)		
Cooking - electricity	382	68.6	15 (3.9%)	367 (96.1%)	1.30	0.52; 3.23
Child support grant (R350.00)						
No	40	7.2	1 (2.5%)	39 (97.5%)		
Yes	387	69.5	17 (4.4%)	370 (95.6%)	1.79	0.23; 13.98
Underlying factors						

Urban/rural status						
Urban	418	75.0	12 (2.9%)	406 (97.1%)		
Rural	139	25.0	8 (5.8%)	131 (94.2%)	2.07	0.63; 6.79

KIBS 2a: Logistic regression table. Weight-for-length >2

Crude logistic regression

Weight-for-length			**>2**	**<2**	**Crude WLZ**	
n total: 657	n	%	n (%)	n (%)	OR	95% CI
Inherent factors						
Sex						
Boy	330	50.2	93 (28.2%)	237 (71.8%)		
Girl	327	49.8	91 (27.8%)	236 (72.2%)	0.98	0.75; 1.29
Age (days)					1.04	0.99; 1.08
Immediate factors						
Breastfeeding						
Never	39	5.9	10 (25.6%)	29 (74.4%)		
Stopped	97	14.8	21 (21.6%)	76 (78.4%)	0.8	0.36; 1.80
Still	425	64.7	121 (28.5%)	304 (71.5%)	1.15	0.58; 2.28
Complementary feeding						
Formula given						
No	375	57.1	11 (26.8%)	30 (73.2%)		
Yes	182	27.7	141 (27.1%)	379 (72.9%)	0.61	0.41; 0.91
Intermediate factors						
Birthweight (kg)					1.14	0.80; 1.63
HIV exposure						
Mother HIV Negative	337	51.3	87 (25.8%)	250 (74.2%)		
Mother HIV Positive	214	32.6	62 (29.0%)	152 (71.0%)	1.17	0.73; 1.88
Breastfeeding after delivery						
Within 1 hour	258	39.3	69 (26.7%)	189 (73.3%)		
After 1 hour	262	39.9	74 (28.2%)	188 (71.8%)	1.08	0.64; 1.80
Distal factors						
Maternal and family factors						
Sibling						

No	249	37.9	69 (27.7%)	180 (72.3%)		
Yes	309	47.0	82 (26.5%)	227 (73.5%)	0.94	0.63; 1.40
Mother's age					1.01	0.98; 1.03
Mother's BMI					**1.05**	**1.01; 1.08**
Mother's highest school grade						
0-7	36	5.5	5 (13.9%)	31 (86.1%)		
8-12	522	79.5	146 (28.0%)	376 (72.0%)	2.41	0.96; 6.03
Returned to school after birth						
No	223	33.9	53 (23.8%)	170 (76.2%)		
Yes	27	4.1	7 (25.9%)	20 (74.1%)	1.12	0.43; 2.91
Returned to work after birth						
No	515	78.4	139 (27.0%)	376 (73.0%)		
Yes	43	6.5	12 (27.9%)	31 (72.1%)	1.05	0.53; 2.05
Socio-economic factors						
Household information						
Water - public	245	37.3	56 (22.9%)	189 (77.1%)		
Water - private	405	61.6	128 (31.6%)	277 (68.4%)	1.56	0.81; 3.01
Toilet - pit	410	62.4	109 (26.6%)	301 (73.4%)		
Toilet - flush	240	36.5	75 (31.3%)	165 (68.7%)	1.25	0.70; 2.26
Electricity in house						
No	70	10.7	16 (22.9%)	54 (77.1%)		
Yes	580	88.3	168 (29.0%)	412 (71.0%)	1.37	0.79; 2.39
Cooking - other	136	20.7	35 (25.7%)	101 (74.3%)		
Cooking - electricity	514	78.2	149 (29.0%)	365 (71.0%)	1.18	0.69; 2.01
Child support grant (R350.00)						

No	48	7.3	15 (31.3%)	33 (68.7%)		
Yes	507	77.2	134 (26.4%)	373 (73.6%)	0.79	0.37; 1.69
Underlying factors						
Urban/rural status						
Urban	420	63.9	105 (25.0%)	315 (75.0%)		
Rural	237	36.1	79 (33.3%)	158 (66.7%)	1.50	0.63; 3.55

KIBS 2b: Linear regression table. Weight-for-length >2

Crude linear regression

Weight-for-length.			**Wasted**	**Not wasted**	**Crude WLZ**	
n total: 557	n	%	n (%)	n (%)	OR	95% CI
Inherent factors						
Sex						
Boy	277	49.7	62 (22.4%)	215 (77.6%)		
Girl	280	50.3	60 (21.4%)	220 (78.6%)	0.94	0.63; 1.41
Age (days)					1.01	0.99; 1.03
Immediate factors						
Breastfeeding						
Never	26	4.7	4 (15.4%)	22 (84.6%)		
Stopped	83	14.9	16 (19.3%)	67 (80.7%)	1.31	0.23; 7.51
Still	325	58.3	68 (20.9%)	257 (79.1%)	1.45	0.28; 7.61
Complementary feeding						
Formula ever given						
No	264	47.4	4 (14.3%)	24 (85.7%)		
Yes	169	30.3	84 (20.7%)	322 (79.3%)	0.72	0.45; 1.15
Intermediate factors						
Birthweight (kg)					2.16	1.48; 3.17
HIV exposure						
Mother HIV Negative	265	47.6	56 (21.1%)	209 (78.9%)		
Mother HIV Positive	163	29.3	32 (19.6%)	131 (80.4%)	0.91	0.61; 1.36
Breastfeeding after delivery						
Within 1 hour	216	38.8	42 (19.4%)	174 (80.6%)		
After 1 hour	185	33.2	41 (22.2%)	144 (77.8%)	1.18	0.71; 1.96
Distal factors						
Maternal and family factors						
Sibling						

No	167	30.0	37 (22.2%)	130 (77.8%)		
Yes	266	47.8	51 (19.2%)	215 (80.8%)	0.83	0.47; 1.49
Mother's age					0.99	0.97; 1.03
Mother's BMI					1.03	0.99; 1.08
Mother's highest school grade						
0-7	31	5.6	7 (22.6%)	24 (77.4%)		
8-12	402	72.2	81 (20.1%)	321 (79.9%)	0.86	0.40; 1.87
Returned to school after birth						
No	177	31.8	41 (23.2%)	136 (76.8%)		
Yes	26	4.7	3 (11.5%)	23 (88.5%)	0.43	0.09; 2.17
Returned to work after birth						
No	382	68.6	74(19.4%)	308 (80.6%)		
Yes	51	9.2	14 (27.5%)	37 (72.5%)	1.57	0.91; 2.73
Socio-economic factors						
Household information						
Water - public	248	44.5	50 (20.2%)	198 (79.8%)		
Water - private	299	53.7	71 (23.8%)	228 (76.2%)	1.23	0.68; 2.24
Toilet - pit	389	69.8	76 (19.5%)	313 (80.5%)		
Toilet - flush	158	28.4	45 (28.5%)	113 (71.5%)	1.64	0.81; 3.32
Electricity in house						
No	90	16.2	20 (22.2%)	70 (77.8%)		
Yes	457	82.0	101 (22.1%)	356 (77.9%)	0.99	0.50; 1.97
Cooking - other	164	29.4	32 (19.5%)	132 (80.5%)		
Cooking - electricity	382	68.6	89 (23.3%)	293 (76.7%)	1.25	0.64; 2.45

Child support grant (R350.00)						
No	40	7.2	8 (20.0%)	32 (80.0%)		
Yes	387	69.5	80 (20.7%)	307 (79.3%)	1.04	0.49; 2.22
Underlying factors						
Urban/rural status						
Urban	418	75.0	85 (20.3%)	333 (79.7%)		
Rural	139	25.0	37 (26.6%)	102 (73.4%)	1.42	0.62; 2.24

Appendix 4 – Use of figure permissions

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