

# **Evaluation of a potato-based food product for acceptability, growth and diarrheal management in children**

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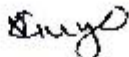
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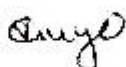
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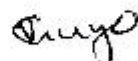
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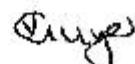
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## ABSTRACT

**Introduction:** The World Health Organization (WHO) ranks diarrhoea as the second greatest killer of children below the age of five years. In South Africa, children's illness and death is highly attributable to diarrhoea and malnutrition, with undernutrition and HIV infections predisposing children to the illness due to suppressed immune system. Therefore, the malnutrition status of children synergically worsens as a result of each episode of diarrhoea. This study was a contract research with Feed My Starving Children (NGO) for testing a potato-based food product for nutritional impact and relief for diarrhoeal episodes.

**Objectives:** The purpose was to evaluate the acceptability of the product as a nutritional supplement for child growth and as a first food to complement oral rehydration and other efforts to reduce the impact and support the resolution of the symptoms of chronic and acute diarrhoea in children between the ages of two and thirteen in a Qwa-Qwa community (the experimental group), and in pre-schools in the Vaal region of Gauteng (the control group).

**Study design:** A baseline cross-sectional and subsequent experimental study design was used.

**Methods:** The study purposively enrolled children between the ages of 2-12 years, in experimental group of 96 and control group of 100. The study was conducted in three phases the first of which was a cross-sectional baseline survey in which the measurements included questionnaires to establish the nutritional status, diarrhoea prevalence in the two groups and sensory analysis questionnaire to establish acceptability of the potato-based based food product by the experimental group only. The anthropometric measurements included weight and height; the diarrhoea measurements included prevalence, duration and severity; while the sensory analysis included the taste, texture and appearance of the product. The second phase was the intervention programme in which the experimental group consumed the product for six weeks. The measurements taken included height, weight and diarrhoea episodes on weekly bases in the two groups. In the last phase all the measurements done at baseline were repeated to

determine if the potato-based food intervention had an impact on the experimental group with respect to nutritional status and diarrhoeal mitigation as well as acceptability of the food product.

**Data analyses:** All data was captured on Excel spreadsheets. The WHO growth standards were used to make a statistical comparison of the anthropometric indicators using WHO anthroPlus programme version 1.0.02. Data for diarrhoea and sensory analysis was analysed using the Statistical Package for Social Sciences (SPSS) version 20.0 for descriptive statistics (frequencies, means and standard deviations). Two tailed tests were done in order to determine any statistical differences between baseline and follow up measurements of both experimental and control groups.

**Results: Anthropometric:** The total underweight in the experimental group decreased significantly (3.6 percent,  $p=0.015$ ) while the control group increased by 2.0 percent ( $p=0.004$ ). The results for stunting did not show any improvement specifically for the severely stunted children where stunting increased by 0.3 percent and 1.1 percent for the experimental and control group respectively. Conversely, the severely stunted and the stunted group decreased by 2.9 percent and two percent for the control group. As for severely wasted the results were unexpected where the experimental group had an increase of 0.1 percent while in the control group the severely wasted decreased to zero percent. However in both the experimental and control groups the number of wasted increased by 1.5 and 0.2 percent respectively.

**Diarrhoea:** For the experimental group, there was a total reduction of diarrhoea incidence between baseline and immediately after the intervention ( $n=93$ ,  $p=0000$ ). Whereas for the control group the incidence remained largely unchanged with no statistical significant change of ( $n=93$ ,  $p=063$ ). The results showed that the intervention was effective in reducing stool frequency and consistency.

**Sensory analyses:** The overall liking of the product was high. The two tailed significant tests results showed a high significant change in liking of the potato-based food product between baseline and follow up, texture ( $n=72$ ,  $p=000$ ) with a mean and standard deviation of 0.667 and 1.178, taste ( $n=72$ ,  $p=0.0180$ ) with a

mean and standard deviation of 0.413 and 1.352 and appearance ( $p=0.00$ ,  $n=72$ ) mean and standard deviation of  $0.968 \pm 1.270$  respectively.

**Conclusions and recommendations:** The study revealed that the potato-based food intervention was effective in reducing the underweight, diarrhoea eradication and was very acceptable by the children due to its similarity to local dishes. Hence the potato-based food product can be used in similar intervention programmes as a first relief measure in management of diarrhoea. In future similar interventions should be carried out over a longer period of time in order to get conclusive results especially where nutritional impact of the food intervention has to be measured.

**Key words:** malnutrition, undernutrition, diarrhoea, sensory analysis, potato-based food product

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## **GLOSSARY OF TERMS**

AIDS	Acquired Immune Deficiency Syndrome
BMI	Body mass index
BTech	Baccalaureus Technologies
CBS	Corn soya blend although
CDC	Centre for Disease control
CHIP	A child health identification programme
CSL	Centre for Sustainable Livelihoods
DHIS	District Health Information System
DoH	Department of Health
DWA	District Water Authority
E coli	Escherichia coli
et al	et alii (meaning many others)
ETEC	Enterotoxigenic escherichia coli
FAO	Food and Agriculture Organisation
FDA	U.S Food And Drug Administration
FMSC	Feed My Starving Children
g	grams
GAIN	Global Alliance for Improved Nutrition
GHI	Global Hunger Index
HIV	Human Immune Virus
HSSF	Health Sector Strategic Framework
H/A	Height-for-Age
INGO	International Non-governmental Organizations
INP	Integrated Nutrition Programme
ISRDP	Integrated Sustainable Rural Development Programme
IZiNCG	International Zinc Consultative Group
Jr	Junior
Kcal	Kilocalories

Kgs	Kilograms
KJ	Kilojoules
MDG	Millennium Development Goal
mg	milligrams
MOST	USAID micronutrient Program
MRC	South African Medical Research council
NGO	Non-governmental Organization
NRB	National Bureau of Asian Research
NSNP	The National Schools Nutrition Program
NEP	Nutrition Education Programme
ORS	Oral Rehydration Solution
PATH	Personal Awareness through Health
PEM	Protein energy malnutrition
QINP	Qwa-Qwa Integrated Nutrition Programme
RDA	Recommended Dietary Allowance
RDI	Recommended Daily Intake
S.A	South Africa
SD	Standard deviation
SOS	Save our Soul
SPSS	Statistical Package for Social Sciences
SSA	Sub Sahara Africa
TOBEC	Total Body Electrical Conductivity
UNDP	United Nations Economic Commission for Africa
UNICEF	United Nations International Children's fund
USAID	United State Agency for International Development
UN	United Nations
UNAIDS	Joint United Nations on HIV/AIDS Programme
U.S	United States
VUT	Vaal University of Technology

WBS	Wheat soya blend
WHO	World Health Organisation
W/A	Weight- for -age
W/H	Weight-for-height
WFP	World Food Programme
TB	Tuberculosis
USA	United State of America
USB	United Soybean Board
ZAR	South African Rand

## LIST OF SYMBOLS

%	Percent
</>	smaller than /greater than
U5	Under five
±	plus or minus
&	and
n	sample size
$p$	probability value
=	equals

## **CHAPTER 1**

### **THE PROBLEM AND ITS SETTING: PREVALENCE OF MALNUTRITION AND DIARRHOEA GLOBALLY**

#### **1.1 INTRODUCTION**

It has been reported by the United Nations Children's Fund (UNICEF, 2009:1) that in developing countries 12 million children below the age of five die annually from preventable diseases and conditions. In total, 42 countries are responsible for 90 percent of these deaths with 36 being in sub-Saharan Africa (SSA) (Fotso, Ezech, Madise & Ciera, 2007:1471), and two million directly or indirectly linked to malnutrition (UNICEF, 2009:1). In addition, deaths attributable to diarrhoea, but due to malnutrition and other causes, are estimated at around 1.87 million globally (Nair, Ramamurthy, Bhattacharya, Krishnan, Ganguly, Saha, Rajendran, Manna, Ghosh, Okamoto & Takeda, 2010:1). An average of one thousand children die every hour yet there are simple and affordable interventions that can be made available. The highest concentrations of such deaths are among the less privileged and uneducated households (WHO, 2007b:1).

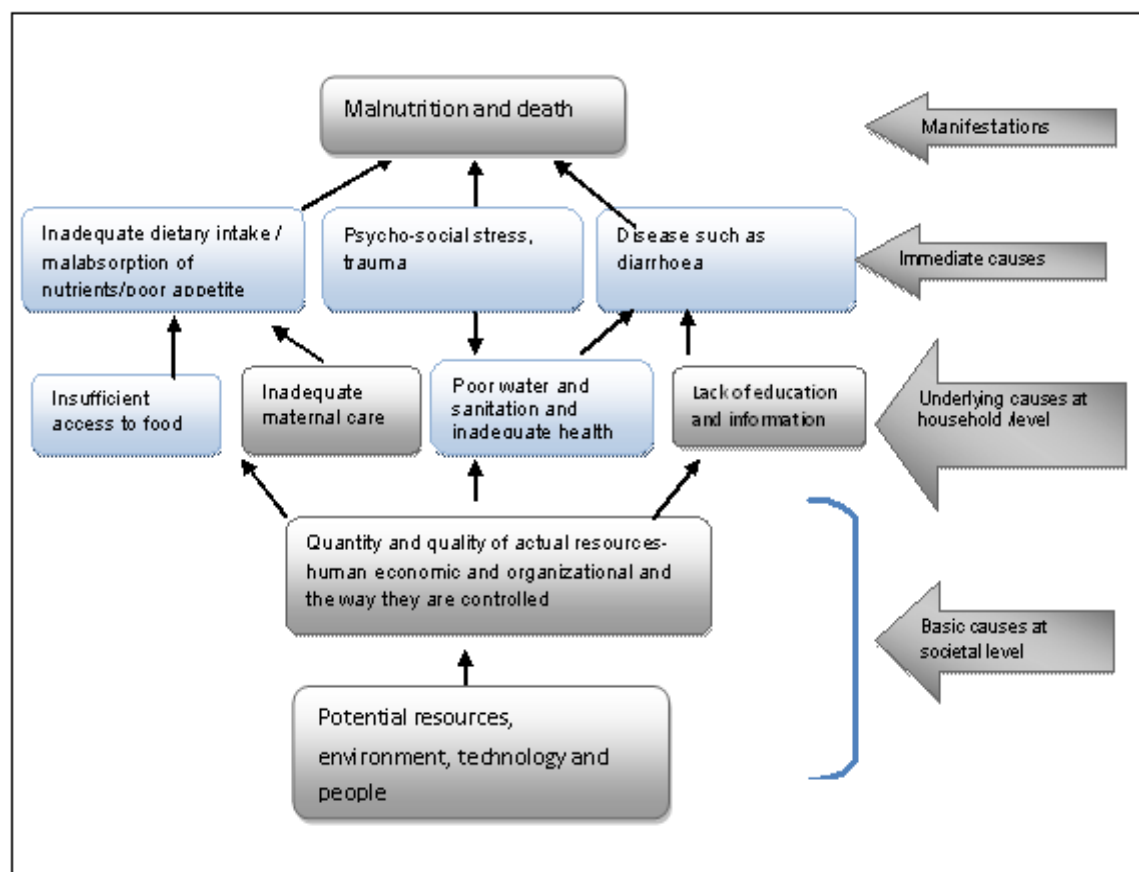
#### **1.2 MALNUTRITION**

According to Lutz and Przytulskik (2008:6), malnutrition occurs when one has ingested too much or too little nutrients required by the body cells. There is a range of intake of any nutrient compatible with optimal health (Lutz & Przytulskik, 2008:6), either side of which is malnutrition, a term that includes both undernutrition and overnutrition (Steyn, 2008:166). An individual nutritional requirement is dependent on age, gender, level of activity and physiological status. Insufficient and inappropriate food supplies or early cessation of breastfeeding is a common cause of malnutrition. Adequacy may be measured both quantitatively and qualitatively, with a diet that is varied and contains adequate or sufficient proteins, energy, vitamins and minerals. It should also be

acceptable in terms of taste and culture and contain ingredients that are safe and free from toxins and parasites that may be harmful to the body (Steyn, 2008:164).

### 1.2.1 Causes and consequences of malnutrition

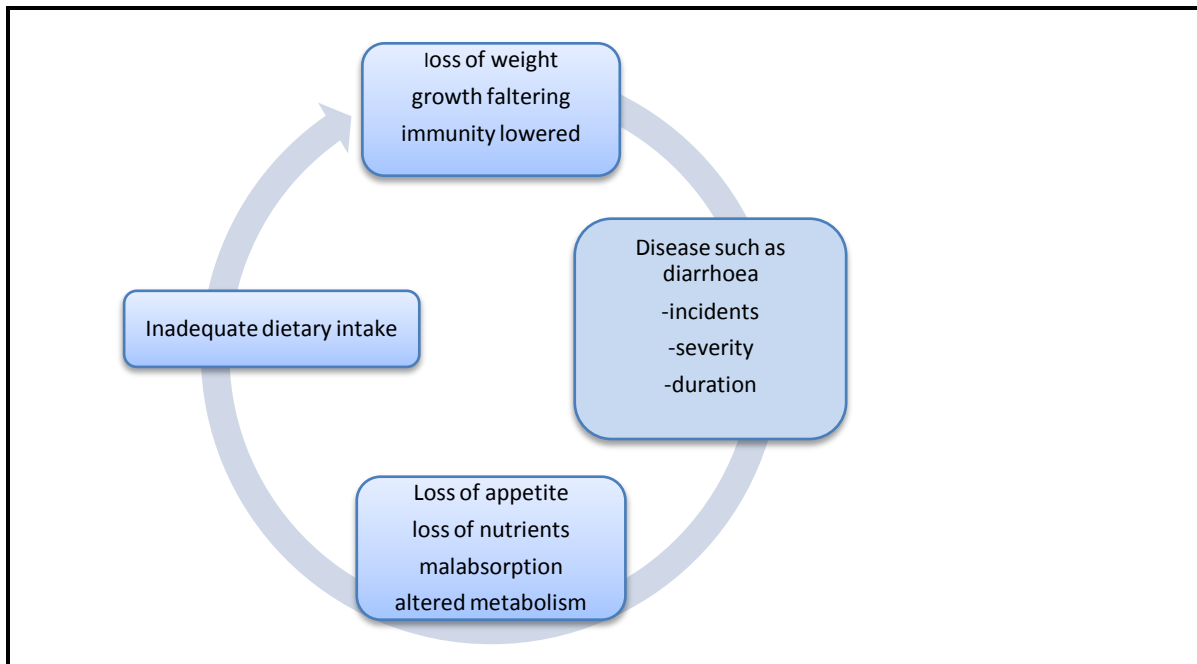
Malnutrition is complex, the development and effects of which can be understood and illustrated using a conceptual framework developed by UNICEF in 1990 and later modified in 2004 (see Figure 1.1, below). The framework shows the relationship between the underlying, immediate and basic causes, its development, the interrelatedness of each factor and how each level is influenced by the other.



**Figure 1.1:** Conceptual framework for understanding child malnutrition, death and disability (UNICEF, 2004)

When children have an inadequate diet their immune system is compromised, hence they have a lowered defence mechanism that results in increased incidence of infection, duration and severity of disease (UNICEF, 1998:2).

Figure 1.2 illustrates the vicious cycle between inadequate dietary intake and disease.

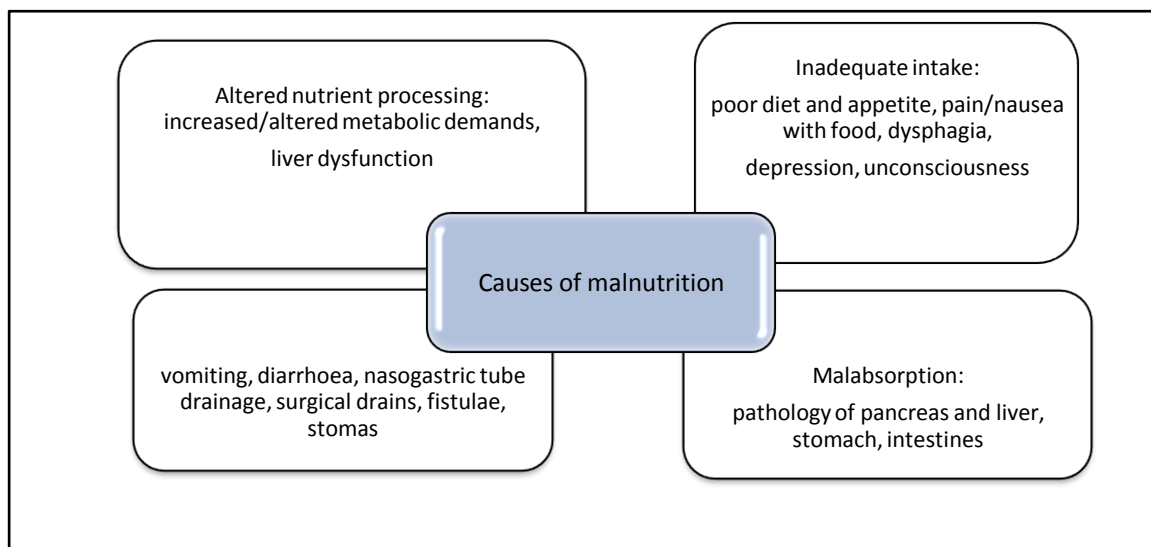


**Figure 1.2:** Cycle of inadequate dietary intake and disease (UNICEF, 1998:2)

Saunders, Smith and Stroud (2010:45) state that in developed countries malnutrition is not mainly a result of inadequate food intake but rather of illnesses, mostly chronic. Reasons include anorexia, which leads to inadequate food intake, impaired digestion and improper absorption of nutrients as a result of chronic liver or small bowel disease. When there is impaired digestion and absorption, nutritional deficiencies occur and may increase the risk of a wide variety of chronic illnesses, the most common of which include chronic kidney disease, childhood leukaemia, central nervous system malignancies, solid tumours and sarcomas, poor or abnormal heart development, neuromuscular disorder and chronic intestinal or colon inflammatory diseases. Saunders and co-authors (2010:45) add that multiple food allergies are problematic in children as they fail to receive adequate nutrients from restricted diets. In addition, some health conditions, such

as surgery or burns, frequently produce a state of malnutrition as the body breaks down stores of protein and may excrete it in the process.

Figure 1.3 (below) gives a summary of causes of malnutrition in which there is prevalence of disease (Saunders *et al.*, 2010:46).



**Figure 1.3:** Causes of malnutrition (adapted from Saunders *et al.*, 2010:46)

Although there may be enough to eat, undernutrition can still occur. The quality of a typical diet in developing countries still consists of high fibre grain products with little variety. Adults may meet their nutritional needs by eating a large amount of this; however children, the elderly and those with increased needs may not be able to meet their nutritional needs. The most common deficiencies are in protein, vitamin A and iron (Smolin & Grosvenor, 2008:725).

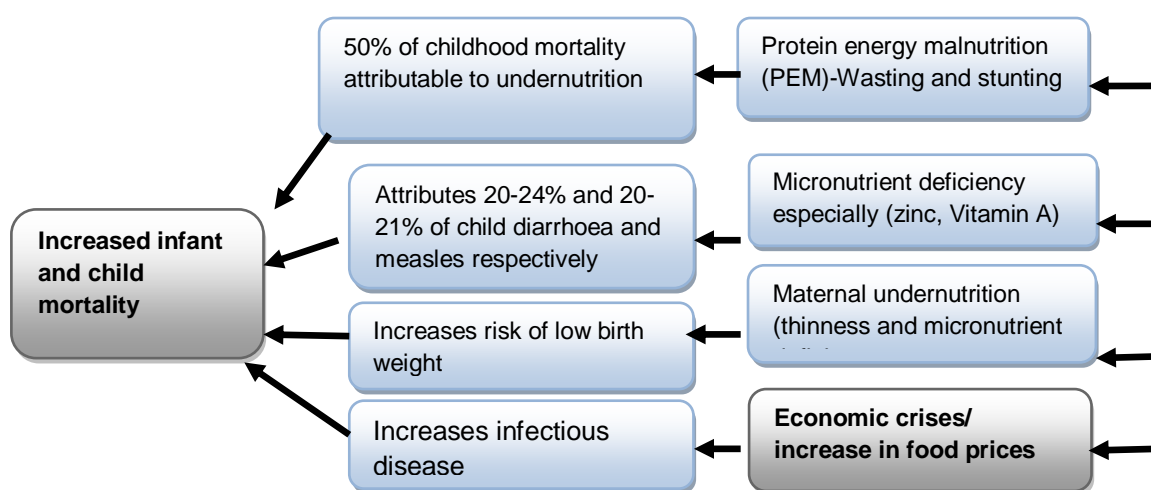
Fotso *et al.*, (2007:208) writes that poor family income makes accessibility to adequate food for many families problematic. Food insecurity at household level or limited ability to acquire nutritious and safe food is a result of poverty. The Food and Agriculture Organisation defines food security as a situation in which people have sufficient physical and economic access to food that is nutritious and safe and are able to meet their food choices and needs for a healthy and active life (Steyn, 2008:164). However, a distinction is made between rural areas, with



agricultural land and domestic food production, and urban areas, with a wide variety of food on the market at affordable prices. Teller and Alva (2008:1) point out the role of political instability in causing malnutrition, with surveys between 1986 and 2008 in 24 SSA countries having revealed that countries which experience war or conflict have high levels of stunted children, for example Somalia, Sierra Leone and the Democratic Republic of Congo.

According to Kavishe (2012:1), culture has a role in determining what is eaten, and some cultural practices may cause malnutrition. For instance, if boys, girls and women are considered less important than men they receive less food. Cultural acceptability of food also contributes to shortages and malnutrition, for example insects are acceptable in some cultures and are a good source of protein, whilst in others they are unacceptable (Smolin & Grosvenor, 2008:724).

Christian (2010:178S) found that economic crises and increases in food prices directly or indirectly increase the vulnerability of children to undernutrition and disease, resulting in early child mortality. Figure 1.4 (below) is an illustration of how the economic crises in 2007 and an increase in prices of food could have threatened child survival. The economic crisis is directly linked to poverty.



**Figure 1.4:** Nutritional pathways by which the economic crises and increase in food prices may affect child mortality (adapted from Christian 2010:178S).

In 2007, the world food crises was characterised by an average increase in prices of 24 percent on staple foods, mainly wheat, corn, rice and sugar; 87 percent for oil; 58 percent for dairy products; and 46 percent for rice. Already complex scenario of food insecurity was exacerbated by these food price increases, impacting most seriously on the world's poor and hungry population (Christian 2010:177S).

Compton, Wiggs and Keats (2010:29) found that more than a quarter of households in 18 out of 21 global surveys adopted various coping strategies in response to the rise in 2007 food prices. These included reduction in dietary diversity and the quality and quantity of food consumed, or even skipping meals. In Haiti, for example, 43 percent of the poorest resorted to eating food from street vendors because, due to economies of scale, it was cheaper. However, street food exposed them to health hazards due to unsanitary preparation conditions. These coping strategies resulted in reduction of major and micro nutrient intake, and thus immunity, underweight, wasting and increased mortality.

From the perspective of Smolin and Grosvenor (2008:723), the human population is growing at a faster rate than food production, particularly in developing countries, the economies of which cannot cope with the rate of population growth and hence contribute to poverty. The authors add that poverty and hunger are central to the problem of undernutrition, with about 1,2 million people in the developing world living below the international poverty datum line of less than one dollar per day in earnings. Poverty also reduces access to proper health care as diseases go untreated, increasing the need for nutrients and further limiting the ability to obtain them from the diet. This vicious cycle results in malnutrition.

The poor have less access to education and therefore it becomes difficult to escape poverty. Lack of education may also lead to poor or inadequate care of infants, children and pregnant women, inturn increasing the risk of malnutrition. Specifically, lack of knowledge about food preparation, food safety and hygienic preparation of food puts the entire household at risk of gastrointestinal disease, another contributor to malnutrition (Smolin & Grosvenor, 2008: 723). Maternal

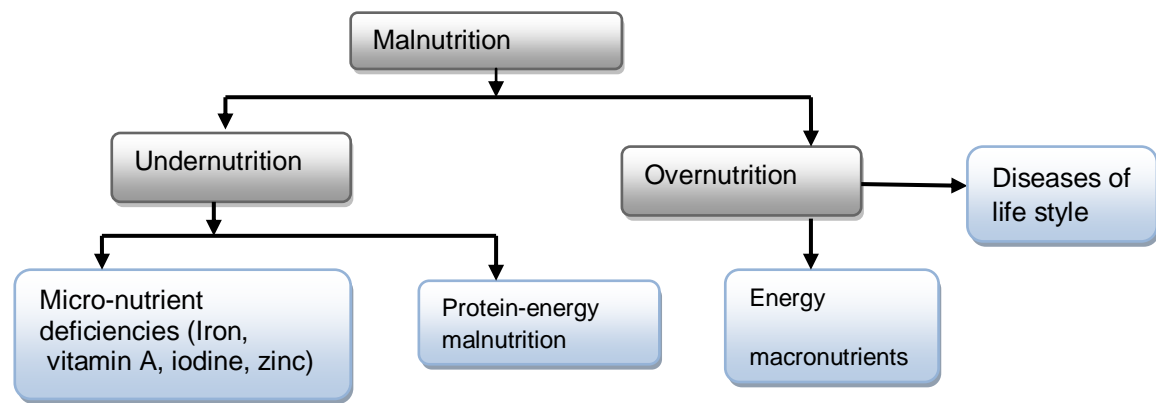
education has been shown to have an influence on the health status of children, with studies in Kenya in 2001 having revealed that children whose mothers had secondary education were taller than those whose parents had no scholastic background (UNDP, 2010:10).

Literature indicates that in developing countries people are migrating from the rural to urban areas, hence poverty and malnutrition are shifting slowly to the urban areas. In recent years the influx of informal settlements and shanty towns has been noted in SSA, including South Africa. Since the settlements are not planned the sanitation and environment are characterised by unhygienic living conditions, such as open sewers and poor drainage (Fotso, 2006:1475). To a large extent, such housing conditions predispose families to a high risk of infection and disease, through use of unclean water and failure to keep food safe. As a consequence, the rate of child undernutrition, child mortality and pregnancy are higher than in more privileged communities (Fotso, 2006:1475).

In addition to poor housing systems, the situation for the above mentioned families is made worse by poor primary health care facilities, a vital component in the severity of disease. On the other hand, development of a sound public health system and improvement in water and sanitation systems have been slow and weak, frustrating efforts to reduce malnutrition (Fotso *et al.*, 2007:208).

### **1.2.2 The two sides of malnutrition**

Malnutrition includes undernutrition and overnutrition. The former can be divided into both protein-energy malnutrition and micronutrient deficiency. The latter refers to excessive intake of energy and macronutrients (see Figure 1.5 below). People are referred to as 'malnourished' in both circumstances (Steyn, 2008:166).



**Figure 1.5:** A classification of malnutrition (adapted from Faber & Wenhold, 2007:393)

#### 1.2.2.1 Overnutrition

Overnutrition occurs when one consumes more nutrients than required by the body, with the inclusion of high or low micronutrient intake or without taking any foods containing micronutrients (GHI, 2010:24). Eating too much food can also result in excessive intake of many nutrients rather than a single nutrient, and so result is overnutrition (Lutz & Przytulski, 2008:7). Steyn (2008:167) argues that overnutrition which results in overweight and obesity is the end result of eating an excess of wrong foods and not taking physical exercise. Overweight is measured by BMI-for-age  $>+1SD$ , and obesity as BMI-for-age for the child  $>+2SD$  (WHO, 2007:1). A diet high in fat, salt and sugar increases the risk of being overweight (Steyn, 2008:167).

When children or adolescents are obese they are likely to grow into obese adults (Kimani-Murage *et al.*, 2010:2). The effects of obesity can be non-fatal, manifested by skin problems, difficulties with respiration, chronic musculoskeletal ailments and infertility; or life-threatening, for example, hypertension, which may lead to stroke, type two diabetes, disease of the gall bladder and certain cancers. Such health challenges may lead to early death, disability, reduction of quality of life, and impaired economic and educational productivity (FAO, 2004:14).

Overnutrition may also be the result of using over-the-counter self-prescribed vitamin and mineral supplements. When ingested these may cause headache, vomiting, bone abnormalities and liver damage. The problem is more common with vitamin A supplement, whilst vitamin D can result in calcium deposits in the soft tissue and irreversible kidney and cardiovascular damage. Excessive intake of fat-soluble vitamins can cause vitamin toxicity or hypervitaminosis (Roday, 2008:171).

Many chronic diseases are a result of lifestyle, also referred to as non-communicable diseases and include diabetes, obesity, hypertension, high levels of cholesterol, stroke, nutrition-induced cancers, tobacco-induced cancers, heart attacks and chronic bronchitis (van Zyl, van der Merwe, van Rooyen, van Wyk, Walsh & Groenewald, 2010:72). Exposure to diets that are unhealthy over a length period of time, smoking of tobacco, hyperlipidaemia, lack of physical activity and sometimes stress are also among the risk factors of diseases of lifestyle. They increase mortality and the morbidity rate (South African Medical Research council, (MRC) 2011:1).

#### 1.2.2.2 Undernutrition

According to Lutz and Przytulski (2008:70) undernutrition occurs in many different circumstances. Groups that are vulnerable to undernutrition are children, pregnant women and the elderly. Undernutrition is often used to describe a variety of nutrient deficiencies and it is caused by consumption of less than adequate nutrients, most of which are linked to the energy intake (Gibney *et.al.*, 2005:62). The main forms of undernutrition are protein energy malnutrition (PEM) and micronutrient malnutrition (Faber & Wenhold, 2007:393).

##### a) Protein energy malnutrition

Protein energy malnutrition (PEM) is a collective term for energy and protein deficiencies usually that occur concurrently in children, usually when diet is limited

to starchy foods. The most affected are those who are growing, developing and healing (Smolin & Grosvenor, 2008:725). Undernutrition is mainly measured using wasting, underweight and stunting. For all the three indicators where a z-score is below -2 the child is undernourished and where the z-score is below -3 the child is regarded as severe undernourished (FAO, 2010a:24; WHO, 2009b:1). PEM is measured in relation to one's age (Steyn, 2008:167).

**Wasting** manifests it self when the child is thinner than expected or is reflected by low weight-for-height ratio in relation to child's age. According to the WHO (2009b:1), a child is regarded as wasted and severely wasted when z-scores for BMI-for-age are below -2 and -3 respectively. It is a measure of acute malnutrition and shows the cumulative effect of undernutrition (UNICEF, 2007a:1), due to poor feeding practices, inadequate food intake, and loss of nutrients due to infections disease or a multiple of these factors.

Availability of food and prevalence of disease can affect wasting in different individuals and populations (Faber & Wenhold, 2007:394), and an advantage of using it in assessing nutritional status of a child is that the exact age of the child is not necessary as it compares height with weight. Wasting can be reversed within a short time and so can provide quick feedback when assessing or evaluating an intervention programme. This is unlike stunting, which cannot be quickly reversed and it is not easy to measure the success of an intervention programme within a short time (Zere & McIntyre, 2003:5).

According to UNICEF (2007a:3), acute malnutrition (wasting) includes three clinical conditions:

1. Marasmus - a condition characterised mainly by wasting away of tissue, muscle and subcutaneous fat. A child with marasmus may have persistent diarrhoea. Marasmus is a result of inadequate proteins and energy and often a lack of all nutrients for a lengthy time (UNICEF, 2007a:3).

2. Kwashiorkor - the main characteristics are oedema, a protruding belly, rapid weight loss, dizziness, tiredness and abnormal hair colour. This condition is a result of a diet deficient in proteins over a long time (Van Voorhees, 2005:2).
3. Marasmic-Kwashiorkor - a condition in which both signs and symptoms of marasmus and kwashiorkor are present (UNICEF, 2007a:3).

**Underweight** is a measure of both chronic and acute malnutrition, defined as low weight for one's age (WHO, 2006a:3). A child whose z-score for weight-for-age is -2 and -3 is regarded as underweight and severely underweight respectively (WHO, 2009b:1). Underweight, acute and chronic malnutrition is difficult to distinguish (Zere & McIntyre, 2003:5). Although all age groups are at risk of being underweight it is more prevalent among children below five years of age and more often during and after the weaning period from six to 24 months (WHO, 2002:7-8).

**Stunting** is diagnosed when one is too short for one's age. It is a measure of one's height against age. A height which is more than two standard deviations less than the international reference value is regarded as stunting (Zere & McIntyre, 2003:5). According to WHO (2009b:1), when height-for-age is below a z-score of -2 the child is regarded as stunting, where as a z-score of -3 is an indication of severe stunting. Stunting also indicates chronic malnutrition, (Faber & Wenhold, 2007:394), and a decrease in linear growth rate is used as an indicator of the wellbeing of a population (Goon, Toriola, Shaw, Amusa, Monyeki, Akinyemi & Alabi, 2011:1471). Stunting, also referred to as 'retarded growth', is one of the main indices of child malnutrition, and is referred to as the most reliable indicator of child nutritional status (Fotso, 2006:1475). Wamani, Astrom, Peterson, Tumwine and Tylleskar (2007:1471) point out that stunting is widely used because it reflects multiple dimensions of child development, environmental conditions in which children live, and health issues. In addition, height in healthy children below five years is not affected by ethnic group or race. Any variations are due to growth faltering, caused by any of the basic, underlying or immediate causes (Wamani *et al.*, 2007:1471). It is also a result of prolonged and recurrent episodes of nutritional inadequacy, continuous ill health and inadequate food intake. The main

deficiencies are in energy, protein, iron and zinc (Fotso, 2006:10), and it will also result in multiple functional disadvantages, such as poor cognitive development and school achievement (Godoy, Nyberg, Eisenberg, Magvanjav, Shinnar, Leonard, Gravlee, Reyes-Garci´A, Mcdade, Asuanca & Tanner, 2010:00).

Malnourished children do not grow properly, and in developing countries estimates indicate that about 30 percent of children below the age of five years are stunted. Stunting during childhood will result in production of smaller adults, with reduced work output and mothers who give birth to low weight babies (Smolin & Grosvenor, 2007:721). On the other hand, children with low birth weight, and those who have been stunted and gained weight in adolescence and adulthood, are more likely to have nutrition-related illness such as abdominal obesity, which increases the risk of morbidity from cardiovascular diseases, hypertension, and diabetes (GHI, 2010:26).

Stunting is associated with a number of functional problems, such as poor socio-economic development and poverty. For this reason it should be looked at in its broader socio-economic context, taking a holistic integrated approach to any intervention that includes socio-economic variable such as housing, sanitation, employment and literacy (Zere & Macintyre, 2003:3).

#### b) Micronutrient deficiency

Micronutrient deficiency is also referred to as ‘hidden hunger’, and accompanies undernutrition and overnutrition. Even if a diet provides too much or adequate energy and protein there is no guarantee that essential micronutrients have been consumed as well, therefore a deliberate effort to include micronutrient rich food should be considered (Smolin & Grosvenor, 2008:725). Whilst micronutrient deficiency affects many people and may not show any clinical signs, it does require attention as it may result in a serious health hazard (Steyn, 2008:167). The negative effects are more pronounced in pregnant women and young children, as child development requires proper absorption of nutrients, psychomotor and mental development and resistance to disease (GHI, 2008:27). Iron, iodine, zinc,



and vitamin A are the major micronutrients which have high clinical significance (Shashidhar, 2011:1). According to Black and co-authors (2003:2232), micronutrient deficiencies, especially of vitamin A and zinc, are commonly attributable to death of children under five from diarrhoea and measles\malaria. These nutritional deficiencies increase the mortality rate in children by 20 to 24 percent (diarrhoea) and 13 to 21 percent (measles\malaria).

Iron, zinc and vitamin A deficiency remain a problem in South Africa, where of every seven children one has poor iron status and 45.3 percent have low zinc status. Low zinc status was seen to be high in children who live in formal urban and formal rural areas (Labadarios, Swart, Maunder, Kruger, Gericke, Kuzwayo, Ntsie, Steyn, Schloss, Dhansay, Jooste, Dannhauser, Nel, Molefe & Cotze, 2008:262-264). Depending on national statistics, vitamin A deficiency affects an average of 40 percent of children, in South Africa, 66 percent (Labadarios *et al.*, 2008:261). It raises the mortality risk and increases the severity of infectious diseases such as malaria and diarrhoea, and is a preventable cause of night blindness (World Bank, 2010:3). Vitamin A is also associated with loss of appetite in children (Faber & Wenhold, 2007:396).

Iron deficiency is estimated to affect between 22 and 76 percent of children below five. It can reduce immune function and impair neurological function (World Bank, 2010:3), affect temperature response to cold environments in children and increase the risk of lead poisoning (Faber & Wenhold, 2007:396). Iodine deficiency may result in reduced physical growth and mental retardation, in turn affecting earnings in adulthood (World Bank, 2010:3).

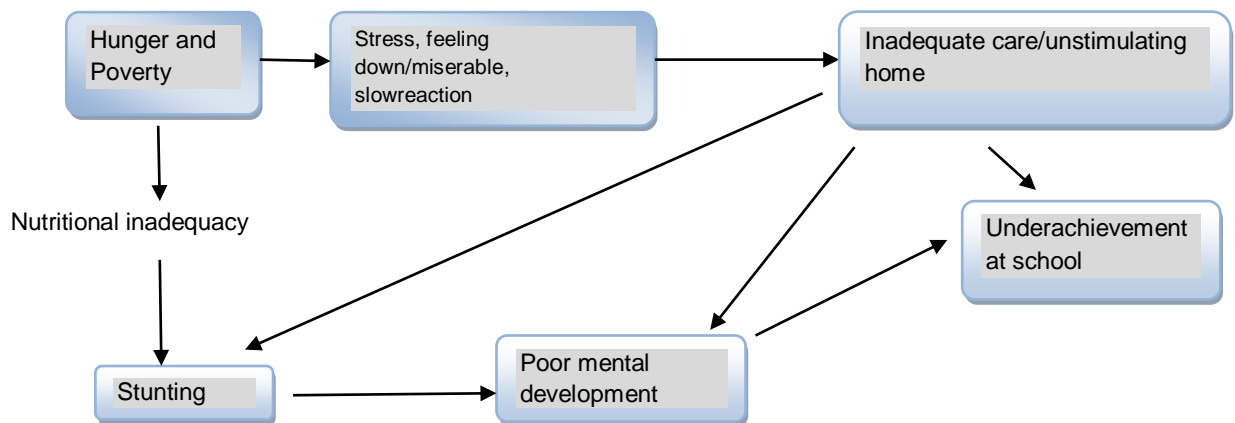
#### 1.2.2.3 Effects and consequences of malnutrition

In a broader context, malnutrition impedes economic growth, poverty eradication and productivity (DoH, 2008:4). Malnutrition is a preventable health inequality during the first five years of life and therefore should be prioritised, as there is a high probability of its being perpetuated in the adult population (Zere & McIntyre, 2003:3).

Gibney and co-authors (2005:62) identify three main consequences of undernutrition, namely physical, psychological and behavioural. Physical undernutrition relates to muscle strength and fatigue, hyposthenia, reduced respiratory and muscle function and reduced cough pressure, which may predispose the sufferer to chest infections. Within physical effects are also impaired immunity system, slow healing of wounds, and reduced final height in women, leading to small pelvic size and small birth weight of infants.

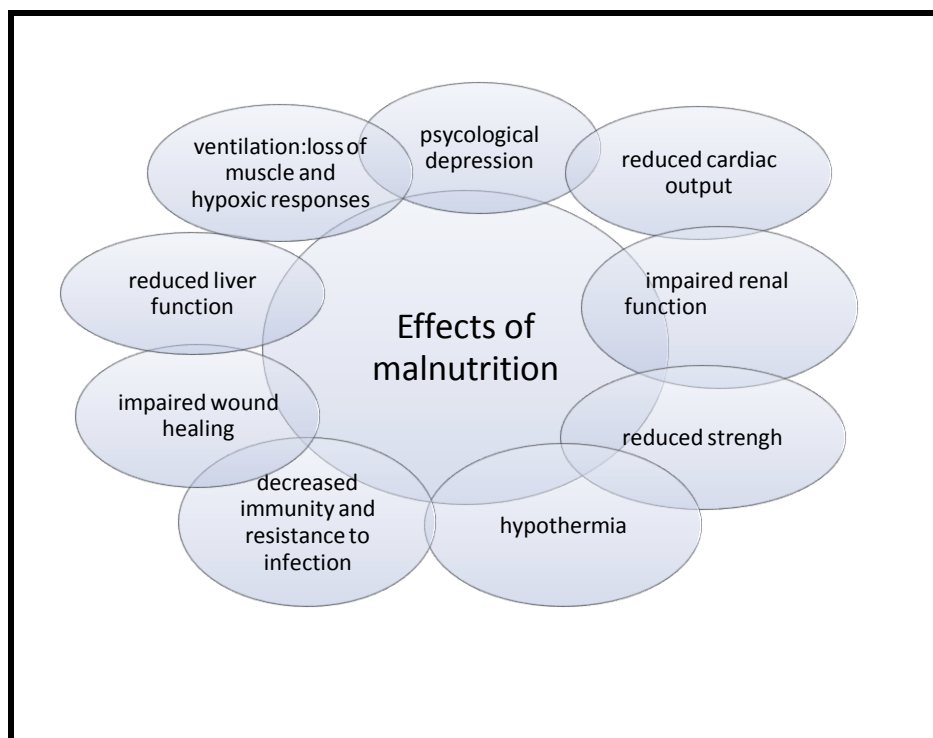
Psychological depression and behavioural consequence include anxiety, reduced will to recover, self-neglect, poor bonding of mother to child, and loss of appetite (Gibney *et al.*, 2005:62). Shashidhar (2011.2) states that chronically malnourished children lack interest in what other children find interesting, exhibit poor attention and have reduced social responsiveness. Undernutrition contributes to poor school achievement and poor developmental achievement, and children who are malnourished face long term sequels such as intellectual and mental impairment (Mamoun, Homedia, Mabyou, Mustasir, Salah, & Adam, 2005:84). According to Fotso (2006:1476), nutritional deficiencies result in increased rate of child deaths from infectious diseases, and poor mental growth, leading to poor performance at school and poor capacity to work in adulthood.

According to estimates by Grantham-McGregor and co-authors (2007:60), over 200 million children below the age of five in South Asia and Africa fail to reach their full development potential. Once children have not developed mentally they perform poorly at school, and later in life will earn poorly and be unable to provide proper care for their families. The poverty will be transmitted from one generation to another. Enrolment of poorly developed children at school leads to below average achievement (Grantham-McGregor *et al.*, 2007:60). Figure 1.6 (below) illustrates how stunting develops and its consequences in relation to school performance.



**Figure 1.6:** A hypothesis of child development, stunting and school achievement. (adapted from Grantham-McGregor *et al.*, 2007:64)

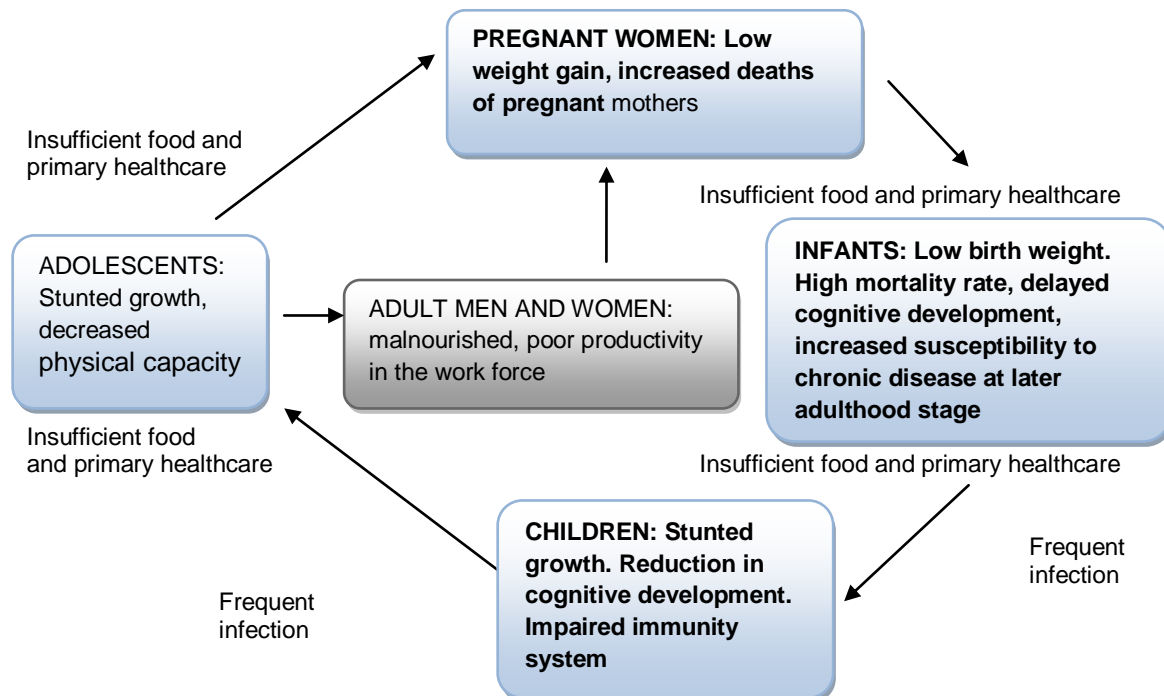
In Figure 1.7 (below), Saunders and co-authors (2010:46) provide a diagrammatic representation of the consequences of malnutrition from a clinical perspective.



**Figure 1.7** Effects of malnutrition (adapted from Saunders *et al.*, 2010:46)

In populations where undernutrition is a chronic problem, there is a cycle of malnutrition Figure 1.8. The cycle begins when a pregnant women consumes a

deficient diet and is very difficult to escape. The women will more likely give birth to an undernourished child whose susceptibility to various diseases is high and may die early (Smolin & Grosvenor 2007:720).

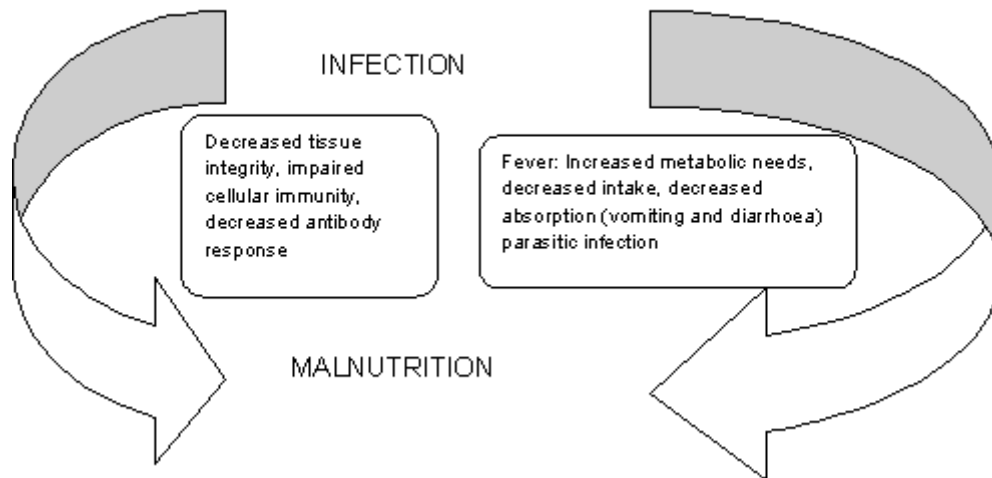


**Figure 1.8:** Malnutrition affects individuals at every stage in life (adapted from Smolin & Grosvenor, 2007:720)

From ten longitudinal studies of children under five years it was found that underweight children have an additional risk of dying from infections. The following ratios showed diseases attributable to being underweight: 61 percent for diarrhoea, 57 percent malaria, 53 percent for pneumonia, 45 percent for measles and 53 percent was for other infectious diseases (Black, Morris & Bryce, 2003:2232).

There is a very close relationship between nutritional status of an individual and the immune system in providing adequate response in the event of an attack or disease. For many centuries it has been recognised that infectious diseases are more common in poorly fed children. The most researched and studied relationship is that of protein energy malnutrition and the immune function (Barasi,

2003:345).



**Figure 1.9:** The cycle of infection and malnutrition (adapted from Rosenberg, 2007:348)

There is a synergy and cyclical relationship between malnutrition and infection, as indicated in Figure 1.9 (above), in which a malnourished child is more prone to infections and diseases, including diarrhoea. Recurrent and frequent infections are a common phenomenon in developing countries and contribute significantly to deterioration in nutritional status through gastrointestinal loss of nutrients (Rosenberg, 2007:348).

The health status of a child when infection begins and the diet at the convalescent stage determine the impact of recurrent infections. The child's appetite is reduced during fever and infection, a situation made worse within some cultures that believe in withholding nutritious food during an illness through increased deterioration nutritional status (Rosenberg, 2007:348).

Undernourished children have a weakened immune system and therefore their bodies cannot resist infection. Diseases which are not life-threatening may

increase the rate of child morbidity, unlike a situation in which well-nourished children will not die of such disease (Smolin & Grosvenor, 2007:721). It is recognised that all aspects of the immune system depend on adequate protein status, hence even immunised children may die from an infectious disease because of the depressed immune system (Barasi, 2003:345).

### **1.3 DIARRHOEA**

Diarrhoea continues to be one of the major killers of children in developing countries, but goes largely underreported as many children are not taken to a hospital or clinic. Treatment and care starts and finishes at home, without any involvement of a health professional (Strina, Cairn, Prado, Teles & Barreto, 2005:408). According to the WHO, it is a condition where one passes at least three or more liquid stool in a day. The bowel movement is usually more frequent than is normal for the individual, however, frequent bowel movement of formed stools or paste should not be classified as diarrhoea. A breastfed child may pass a stool which is loose 'pasty', but this should not be confused with diarrhoea. Diarrhoea is usually a sign that there is either a bacterial, viral or parasitic infection in the intestinal tract (WHO, 2009b:1). The diet and age of the child determine the frequency and number of bowel movements in a day. In diarrhoea the stools are more watery than normal (USAID micronutrient Program (MOST), WHO, UNICEF & International Zinc Nutrition Consultative Group (IZiNCG), 2005:3.1).

Under normal circumstances about 200 millilitres of water is lost through faeces. Everyday about nine litres of fluid enter the gastrointestinal tract via food, water, and excretion, however, under normal conditions about 95 percent is reabsorbed before the faeces are eliminated. In cases of diarrhoea, large amounts of water are lost through the gastrointestinal tract (Smolin & Grosvenor, 2007:409). Diarrhoea occurs when the intestines do not absorb enough water, resulting in frequent watery stools (Smolin & Grosvenor, 2007:92).

With reference to the WHO (2005:8), there are four clinical types of diarrhoea:

1. Acute and watery, which includes cholera. This type of diarrhoea can last several hours or days, the most dangerous aspect being dehydration. If feeding is not continued the child also loses weight.
2. Acute and bloody, also referred to as dysentery. The most dangerous aspect is that the intestinal mucosa is drained and overwhelmed by bacteria, which coupled with loss of nutrients results in malnutrition. In addition, there could be other complications, such as dehydration.
3. Persistent, lasting at least 14 days or more. The most dangerous aspect is an infection that is serious and the person may be dehydrated and malnourished.
4. Severe malnutrition, where there is kwashiorkor /marasmus. The most dangerous consequences are dehydration, vitamin deficiency and mineral infection, which is systemic, and heart failure.

Traveller's diarrhoea is another type of diarrhoea, usually lasting less than one week and developing while a person is visiting or just after returning from other countries (Lutz & Przytulski, 2008:483).

### **1.3.1 Causes of diarrhoea**

The causes of diarrhoea can vary greatly and the nature of it is influenced by the cause. According to the WHO (2009a:1), diarrhoea may be caused by the following:

- **Infection:** Diarrhoea is a sign that there is an infection. This infection could be due to viral, bacterial and/or parasitic organisms. The spread of such disease is mostly through use of water contaminated with faeces, with prevalence common where individuals have no access to purified clean water for household use. In developing countries the most common viral and bacterial causes of diarrhoea are Rotavirus and Escherichia coli (E coli) respectively.
- **Malnutrition:** Malnutrition makes children more vulnerable to diarrhoea and becomes worse with each diarrhoeal episode. A demographic health survey

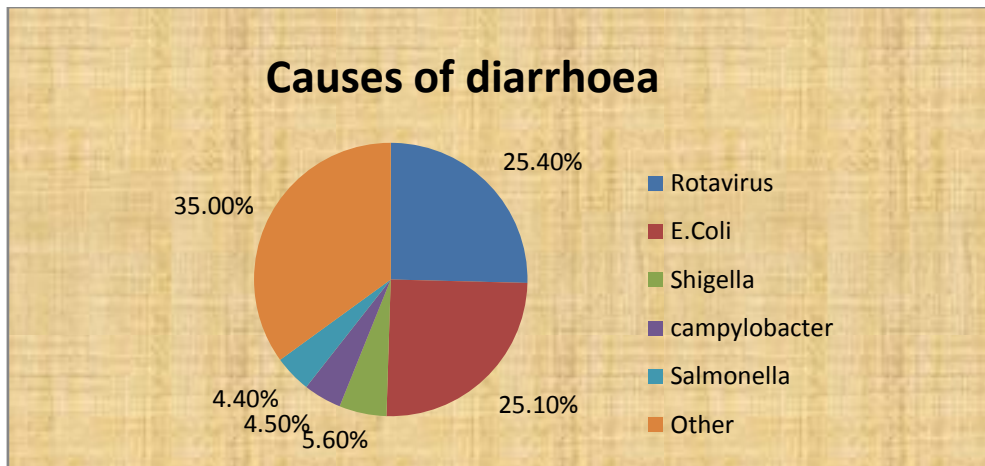
(DHS) of 1999, involving Zimbabwe, Malawi, Ghana, Tanzania, Nigeria and Zambia, found that children who had diarrhoea two weeks before the onset of the survey were significantly underweight (UNDP, 2010:8).

- **Source:** Contaminated water sources cause diarrhoea, especially where there is no proper sanitation in terms of disposal of human waste and poor drainage of sewer, positioning of latrines or septic tanks where the waste can eventually contaminate the ground water source. In addition, faeces from animals also contains diarrhoea-causing microorganisms
- **Other causes:** Poor personal hygiene resulting in spreading of diarrhoea from person to another. Poor storage of food and unhygienic food preparation can cause diarrhoea, directly or through cross-contamination. Irrigation can contaminate crops, especially vegetables, which may be consumed raw, as in salads or partially cooked meals. Consuming seafood from polluted dams contributes to diarrhoeal disease. Thumb sucking can result in faecal oral contamination, leading to diarrhoea. As toddlers' play they pick and eat small dirty or contaminated objects that can lead to diarrhoea (Gerlin, 2006:43).

At risk are people in poor countries with unhygienic infrastructure, poor sanitation and low access to water (Arvelo, Kim, Creek, Legwaila, Puhr, Johnston, Bowen, Masunge, Mintz & Davis, 2010:E1002).

According to the WHO (2010a:8), global estimates about 527,000 children are dying annually from Rotavirus infection. Of these, 230,000 occur in SSA (Madhi *et al.*, 2010:290). Gerlin (2006:45) has broken down the causes of diarrhoea statistically (see Figure 1.10 below), and found almost one hundred intestinal bugs which can trigger diarrhoea, with Rotavirus and E. Coli being on the top of the list, contributing 25.4 and 45 percent respectively (Gerlin, 2006:45).





**Figure 1.10:** Causes of diarrhoea (adapted from Gerlin, 2006:45)

#### 1.3.1.1 Common Infectious pathogens that cause diarrhoea

Cooke (2010:542) groups the common infectious pathogens that cause childhood diarrhoea into the following categories:

- Virus
  - Rotavirus
  - Norovirus
  - Enteric adenovirus
  - Other calicivirus, astrvirus, enterovirus
- Bacteria
  - campylobacter jejuni
  - none-typhoid Salmonella sp
  - shigella spp
  - salmonella typhi
  - shiga-toxin producing E coli (ETEC)
  - vibrio cholera
- Protozoa
  - Cryptosporidium parvum
  - Glardialamblia
  - Entamoebahistolytica
- Unidentified

### 1.3.1.2 Common micro-organism and microbial toxins that cause persistent and bloody diarrhoea as outlined by WHO (2010a:8).

The diarrhoeal incidence and pathogens vary between developed and developing countries, and further by individual country within those groupings. In developed countries, about 70 percent of cases derive from viral pathogens, with 40 percent attributed to Rotavirus, while bacterial infections account for between 10 to 20 percent and less than 10 percent to the protozoa group. In developing countries, pathogens of a bacterial nature are the most common, accounting for 50 to 60 percent of cases. Usually the group consists of Enteropathogenic E.coli, which contributes 25 percent, Camphilobacter, which contributes 10 to 18 percent, Shigella spp and Salmonella spp, which contribute five percent (WHO, 2010a:8).

**Table 1.1:** Common microorganisms that cause diarrhoea (adapted from WHO 2010a:8)

Persistent diarrhoea	Bloody diarrhoea
Cytomegalovirus	
Enteropathogenic Escherichia coli	Shigella
Cryptosporidium	Enteraggregative E.coli
Nontyphodial salmonella	Campylobacter
Microsporida	Enteroinvasive E.coli
Enteraggregative E.coli	Nontyphodial salmonella
Ascaris lumbricoides	Entamoeba histolytica
Giardia lamblia	Shiga toxin-producing E.coli

Viral causes account for 35 percent, of which 15 to 25 percent are of Rotavirus origin, and in many cases mixed and unidentified. Certain organic diseases affecting the intestines may also lead to diarrhoea, the causes of which may not be easily identifiable (Cooke, 2010:542). The number of cases of diarrhoea varies

within developing countries, for example South East Asia and India have more than Africa. The main cause, again Rotavirus, varies from country to country, with 40 percent in Ethiopia and 14 percent in Tanzania, and within 5a country itself. For example, the Rotavirus incidence in Johannesburg averages 14 to 34 percent, whereas in Cape Town it is 18 percent and Durban 25 to 55 percent. Of all the pathogens causing diarrhoea, Rotavirus is the most important aetiological agent, leading to dehydration and hospitalisation of children (Cooke, 2010:543).

Sources of pathogens differ however, often salmonella enteric is a result of consumption of undercooked and raw meat. The source of campylobacter is consumption of uncooked meat, undercooked meat (mainly poultry), untreated water and pets. Diarrhoea outbreaks are linked to consumption of contaminated water and unpasteurised milk (Maragkoudakis, Poulidaki, Papadomanolaki, Alevraki, Papadogianni, Oikonomou & Fanourgiakis, 2011:1). Diarrhoea is dangerous mainly because it causes malnutrition and death (Cooke, 2010:543).

### **1.3.2 The main dangers of diarrhoea**

There are two major dangers arising from diarrhoea, examined in this sub-section.

#### **1.3.2.1 Malnutrition**

The effects of diarrhoea are more pronounced when a child is malnourished, because:

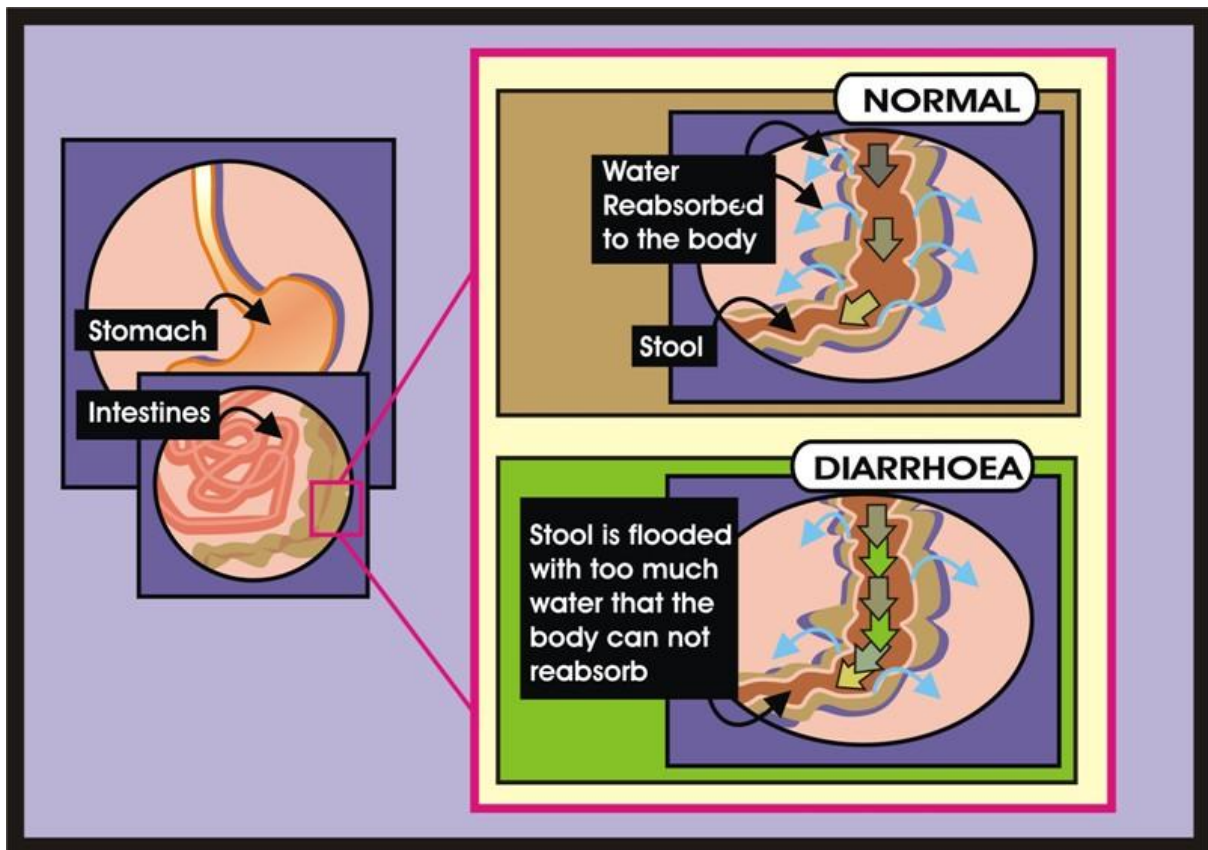
- he or she loses many nutrients during diarrhoeal episodes
- he or she may not have an appetite
- some people withhold food when children have diarrhoea, and may not feed the child for several days even after the symptoms have stopped (MOST *et al.*, 2005:2).

#### 1.3.2.2. Death

If too much water and salt is lost from the body dehydration occurs, and may lead to death. Diarrhoea is a significant cause of dehydration and if diarrhoea and vomiting occur together the risk is even higher because of the large and rapid loss of body fluids. Dehydration should not be treated lightly as it can prove fatal, and prevention of dehydration is the most important aspect in the treatment of diarrhoea. The risk of dehydration is particularly high in children and infants, as well as in the elderly. Diarrhoea in babies and infants can turn fatal rapidly, so it is best to seek medical attention immediately, no matter the cause (MOST *et al.*, 2005:1).

#### 1.3.3 Dehydration from diarrhoea

The body normally takes in salt and water from food and drink, and expels it as urine, faeces and perspiration. When an individual is healthy, salt and water move from the bowel into the blood, but in diarrhoeal cases the bowel does not work normally. The water movement is a reverse of the normal situation in which water moves into the bowel from the blood and very little salt and water gets into the blood. In such a situation there is an imbalance of water and faeces, their being higher than in the faeces lost through diarrhoea. (MOST *et al.*, 2005:2.2). In Figure 1.11 the movement of water in a normal situation is illustrated.



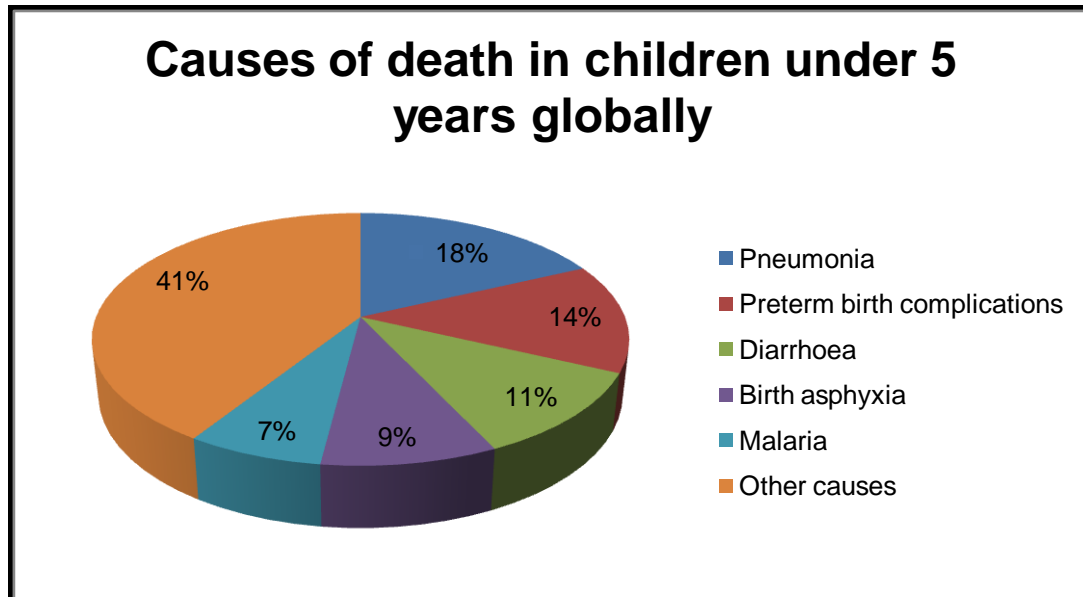
**Figure 1.11:** Movement of water in the intestines in normal circumstances and in diarrhoea state (adapted from Home remedies, 2008:1)

Therefore, dehydration occurs if a considerably higher amount of salt and water is lost from the body than is taken in. The frequency of loose stools passed out at any given time determines the extent or severity of dehydration, where the higher the frequency the more salts and water that is lost. Diarrhoea accompanied by vomiting exacerbates dehydration, the rate of which is high and faster in babies and children, where the climate is hot, and when a child has fever (MOST *et al.*, 2005:2.2).

#### 1.4 GLOBAL OVERVIEW AND PREVALENCE OF MALNUTRITION AND DIARRHOEA

Causes of death in children below five years of age are varied, as indicated in Figure 1.12 (below), but are mainly preventable. Globally, some of these

preventable conditions (disease states) are pneumonia (18%), preterm birth complications (14%), and diarrhoea (11%). Concomitantly the underlying cause of at least one third of all the deaths was attributed to malnutrition (WHO, 2012a:1).



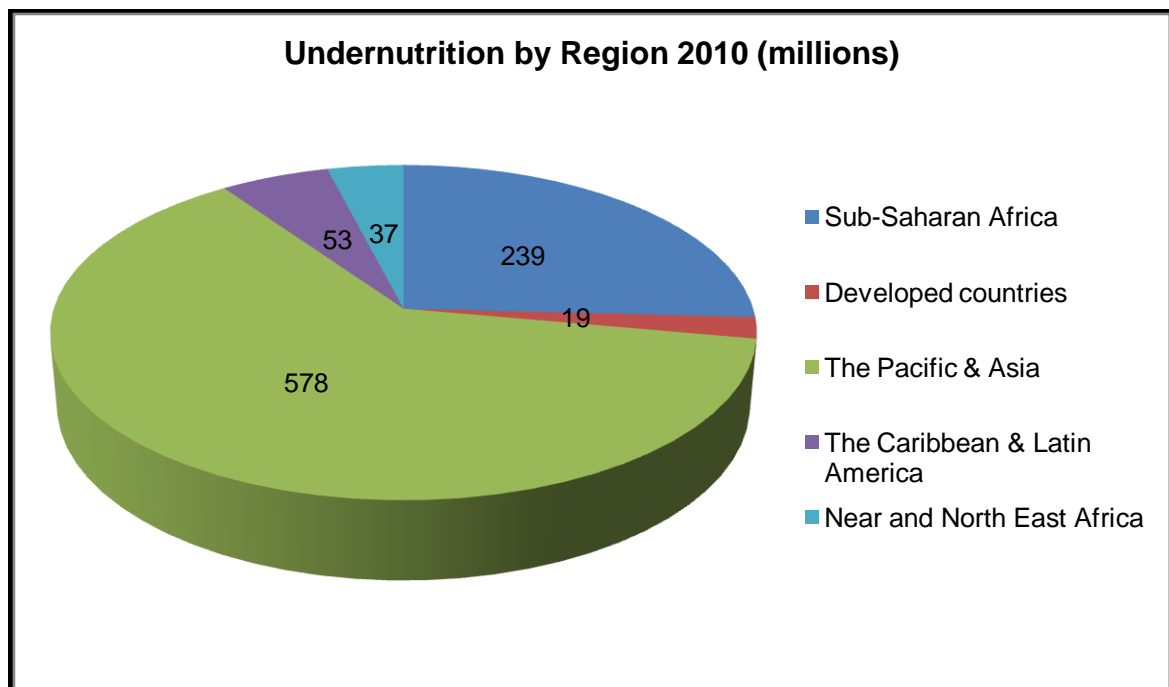
**Figure 1.12:** Causes of death in under five globally (adapted from WHO 2011 statistics, WHO, 2012a:1)

Globally, malnutrition is raising many negative health challenges to both healthcare institutions and authorities (WHO, 2011.1):

- Annual stunting of 171 million children aged under five
- Wasting, with 15 million children under five years being wasted
- Acute malnutrition, with 20 million children being malnourished
- 35 percent of total deaths, thus 3.9 million children, are due to undernutritional risks such as underweight, inadequate or poor breastfeeding, deficiencies of minerals (such as zinc and iron) and vitamins.
- Obesity, with about 43 million children below the age of five being overweight in 2010, and developing countries accounting for 35 million of the global total. The largest numbers of obese children are in Asia, while the rate of growth is regarded as fastest in Africa.

In many developed countries there are pockets of undernutrition, and where children are concerned food shortage is mainly a result of poor parenting or educational deficiencies (Grosvenor & Smolin, 2006:524).

Persistent hunger levels also result in undernourishment around the world, however, the degree of hunger levels differ. Figure 1.13 (below) shows the uneven distribution of the undernourished as a result of persistent hunger levels by region.



**Figure 1.13:** Undernourishment in 2010 by Region (adapted from FAO, 2010a:2)

With reference to the Global Hunger Index (GHI, 2010) the number and proportion of undernourished remains unacceptable, although the figures have declined. In 2010 it was still characterised as serious, with South Asia and Sub-Saharan Africa recording the highest scores (Food and Agriculture Organisation (FAO), 2010b:8).

The persistent hunger levels contribute greatly to prevalence of undernutrition, with almost half of the GHI score consisting of underweight children below the age of five. There is an uneven distribution of underweight children globally, with Africa

and Asia being home to about 90 percent of the world's stunted children (FAO, 2010b:23). A comparison of developed countries with Asia and Africa reflects that trends of child chronic undernutrition remain high across the two continents (WHO 2012b:1).

In developing countries, undernutrition is the main form of malnutrition, with almost 850 million people chronically undernourished (FAO, 2008:1). According to UNICEF (2012:1), in 2010, 18% of children under five in developing countries were underweight. The percentage of children who were underweight, stunted or wasted were, West and Central Africa 23, 40, 11 percent; Eastern and Southern Africa 15, 39, 9 percent; Middle East and North Africa 11, 28 and 6 percent respectively (UNICEF, 2012:1).

Avan and Kirkwood (2010:107) state that the prevalence of undernourishment is higher in rural areas. Cluster surveys from African countries which compared the rate of stunting between the rural and the urban communities reflected that the latter was five to 14 percent higher than the average for urban communities.

In developing countries many children below the age of five are affected not only by malnutrition, unabated hunger or poverty, but also by multiple risks such as home environments that do not stimulate them to grow to their optimum level, and poor basic healthcare practices. These conditions negatively affect their cognitive, psychomotor and emotional development (Grantham-Mcgregor, Cheung, Cueto, Glewwe, Richter & Strupp, 2007:60–70).

According to Grosvenor and Smolin (2006:531), the diet in developing countries is based on high-fibre cereal and may meet the nutritional needs of adults, however, children, the elderly and the sick are at risk as the diet is deficient in the required nutrients. The growth process imposes high metabolic demands throughout childhood, especially in the first year and in the stage of adolescence. The child's brain develops to 90 percent of its adult size by the age of four, thus severe



malnutrition before and during this developmental stage may lead to inadequate development of the central nervous system and as a result the child may never reach its full mental potential (Barasi, 2003:141).

In developing countries children are reaching adolescence undernourished, and hence vulnerable to disease or possibly early death. On the other hand, those living in high income countries are entering adolescence overweight, which poses a negative health consequence as they grow into adulthood. It is imperative that they receive support with an optimum diet, complemented by physical activity (WHO, 2008:1).

Diarrhoea remains a child burden in low and middle income countries due to inadequate access to proper sanitation, inadequate breastfeeding, and deficiency of vitamin A and zinc. On the other hand, studies have shown that diarrhoea prevalence is associated with risk of stunting and/or delayed growth attainment (Walker, Perin, Aryee, Boschi-Pinto & Black, 2012:1471).

Rotavirus, the common cause of diarrhoea results in severe dehydration in children worldwide and is responsible for an estimate two million diarrhoea episodes requiring hospital care, 111 million episodes requiring home care, and about 400,000 deaths of children below five. About 82 percent of such cases of diarrhoea are within the poorest countries. In SSA, Rotavirus diarrhoea is also associated with dehydration and nutritional status of children (Nakawesi, Wobudeya, Ndeezi, Mworosi, Tumwine, 2010:1471).

Studies conducted in Bangladesh, the Philippines and Uganda, of children with serious illness requiring admission at hospitals, 50 to 79 percent of measles cases were followed by diarrhoea and pneumonia (Black, Morris, & Bryce, 2003:2232).

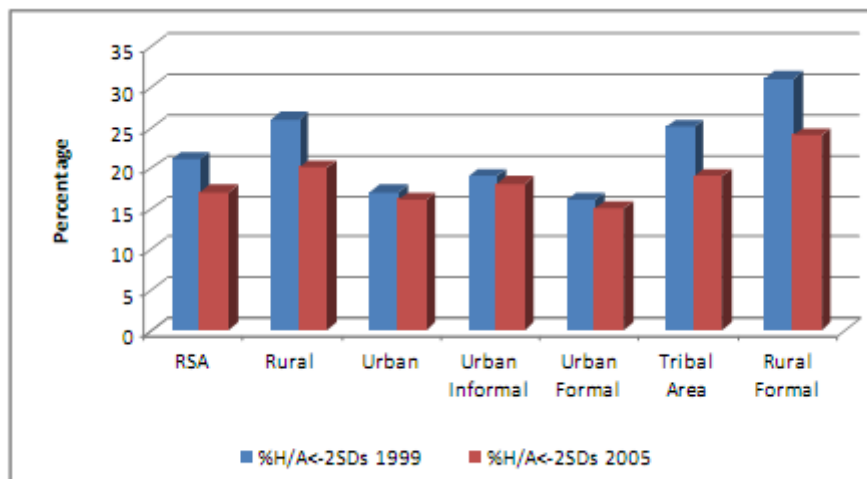
## **1.5 PREVALENCE OF MALNUTRITION IN SOUTH AFRICA**

While economic performance and hunger are inversely related, the assumption may not hold in some cases. For example, in South Africa, although there has been high economic growth, there has not been meaningful change in the socio-economic status of the majority of people, about 57 percent of whom live in poverty, with almost 80 percent of households at risk of hunger (Steyn, 2008:152). South Africa continues to be challenged by child undernutrition, which is a result of poor and inadequate diet and increased infections in young children. A study by Oldewage-Theron and co-authors (2006:804) in the Vaal region indicated that the underlying cause of malnutrition can be attributable to inadequate care of the vulnerable, such as the elderly and children, and food insecurity at household level. In addition, the FAO (2004:11) found insufficient basic services such as poor sanitation, poor housing, and inadequate primary health care and education as among the underlying causes of malnutrition.

As with other developing or partly developing countries, South Africa has the co-existence of both undernutrition and overnutrition in children. Although various nutritional and primary healthcare programmes for children have been initiated over the last decade, findings from various pieces of research indicate that malnutrition and child health have not been reduced significantly at national level (GAIN, 2009:2). A study by Kimani-Murage, Kahn, Pettifor, Tollman, Dunger, Gómez-Olivé and Norris (2010:10) in rural Mpumalanga confirmed the co-existence of overnutrition and undernutrition in South African children and adolescents living in the rural areas. The study also showed persistent undernutrition of children, even though household food insecurity was being addressed through child support grants. The study also indicated that adolescent boys were more undernourished than girls or their counterparts in urban areas, and confirmed previous studies that had revealed delayed puberty in boys in other sub-Saharan countries in which malnutrition prevails.

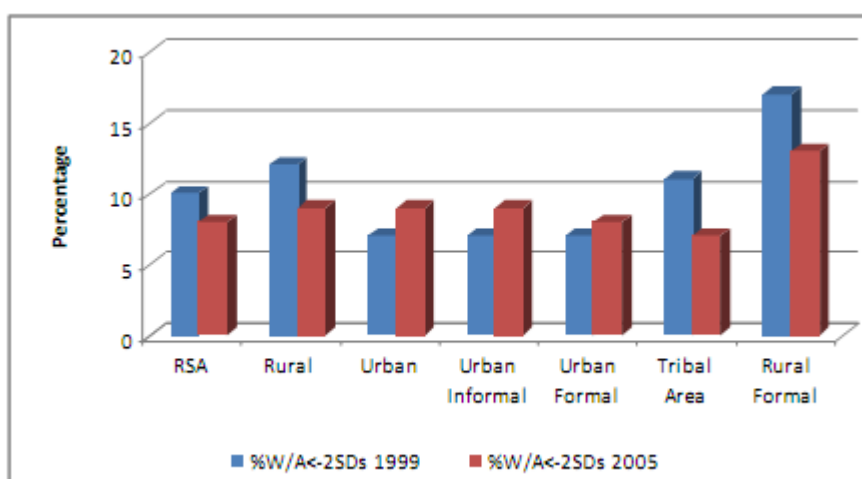
In South Africa, children's illness and death is largely attributable to malnutrition. At the national level, from the two nutritional surveys of 1999 and 2005, stunting and underweight in South Africa remains a challenge, affecting one in five and one in ten children respectively (Labadarios, Swart, Maunder, Kruger, Gericke, Kuzwayo, Ntsie, Steyn, Schloss, Dhansay, Jooste, Dannhauser. Nel, Molefe & Kotze, 2008 suppl. 2:256).

The statistics in Figure 1.14 (below) indicate a mean stunting prevalence decrease at national level from 21.6 percent to 18 percent, with the greatest overall decrease in rural areas, from 26.5 to 20.3 percent. However, at provincial level Free State and Northern Cape the levels were among the highest in children, with percentages of 28.2 and 27.7 respectively (Department of Health, 2008a:9).

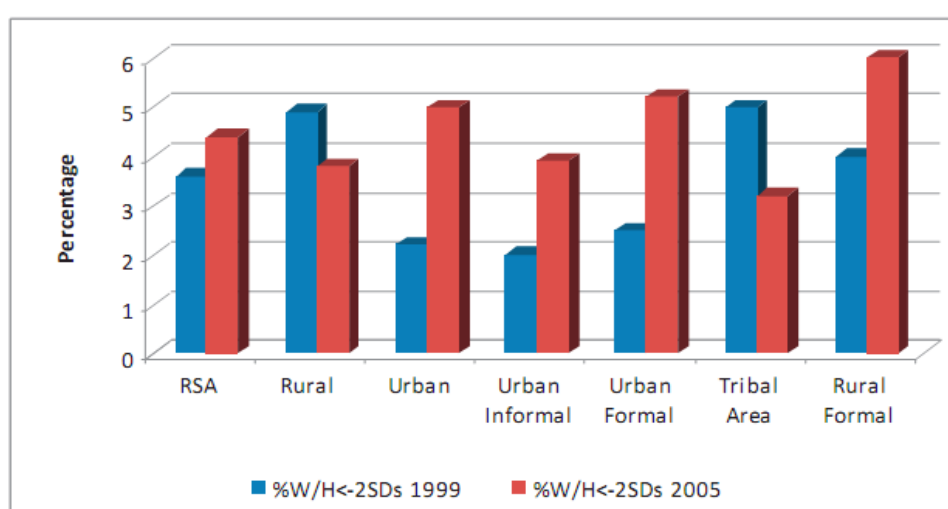


**Figure 1.14:** Stunting for children 1-9 years in South Africa at national level by area of residence, 1999 and 2005 (Department of Health, 2008a:8)

In Figure 1.15 (below), although there was a marginal decrease in underweight at national level it was not statistically significant between 1999 and 2005. The prevalence of underweight cases showed an increase in children living in the three urban areas, while there was a noticeable decrease in the rural areas, from 18.1 to 12.9 percent in formal rural areas (Department of Health, 2008a:8).

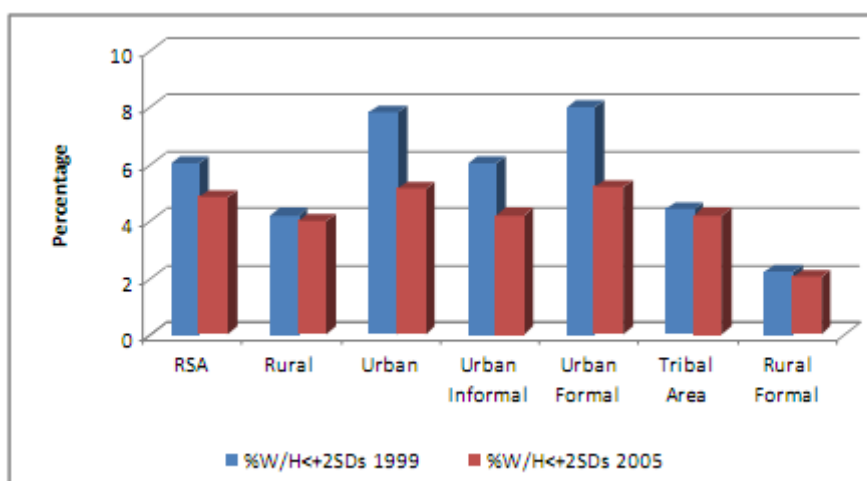


**Figure 1.15:** Prevalence of underweight in children in South Africa at national level, 1-9 years, 1999-2005 by area of residence (Department of Health, 2008a:8)



**Figure 1.16:** Prevalence of wasting in children in South Africa at national level, 1-9 years, 1999-2005 by area of residence (Department of Health, 2008a:9)

As illustrated in Figure 1.16 (above), wasting in children decreased mainly in the rural areas from 4.9 to 3.8 percent, and in tribal areas from 4.9 to three percent, however, it more than doubled in urban areas, from two to 4.8 percent), 1.9 to 3.8 percent for urban informal and 2.2 to 5 percent for urban forma (Department of Health, 2008a:8).



**Figure 1.17:** Overweight in children aged 1-9 years nationally by area of residence (Department of Health, 2008a:9)

There was an overall marginal decrease in overweight at national level between 1999 and 2005, as shown in Figure 1.17 (above), from 5.5 to 4.8 percent. The highest decrease was in urban from 7.7 to 4.9 percent, urban informal settlement from 5.9 to 4 percent, and urban formal settlements from 7.8 to 5.1 percent. Children aged one to three had the highest prevalence rate of overweight and obesity, which accounted for 19.3 percent, while those in urban formal settlements accounted for 15 percent. At provincial level, Gauteng, KwaZulu-Natal and Eastern Cape had the high percentage of overweight and obese children (Department of Health, 2008a:8).

Table 1.2 (below) shows the Free State, Northern Cape and Limpopo as having the highest stunting rate at 28.2, 27.2 and 23.8 percent respectively, which was higher than the national average of 18.0 percent. On the other hand, wasting was very high in Northern Cape, Western Cape and Mpumalanga, with percentages of 19.1, 11.5 and 7.5 respectively. This was also higher than the national average of 4.5 percent.

**Table 1.2:** Stunting and wasting in children by province in 2005 (adapted from Berry, Hall & Hendricks, 2010:1)

Province	Stunting	Severe Stunting	Wasting	Severe Wasting
Free State	28.2	7.0	2.8	-
Northern Cape	27.7	8.5	19.1	-
Western Cape	12.0	0.5	11.5	4.4
North West	15.1	4.9	3.2	-
Mpumalanga	17.8	5.7	7.5	2.3
Limpopo	23.8	8.3	4.4	0.4
KwaZulu-Natal	15.1	3.0	1.3	-
Gauteng	16.8	5.2	1.0	3.3
Eastern Cape	18.0	6.5	4.1	1.4
<b>South Africa</b>	<b>18.0</b>	<b>5.1</b>	<b>4.5</b>	<b>1.0</b>

The present levels of stunting and vitamin A deficiency result in more than 10,000 deaths at an annual level in South Africa. With reference to the latest labour force estimates, close to ZAR1049 million is lost annually due to iron deficiency and anaemia alone. This indicates how serious the effect of malnutrition can be in the future development of South Africa (GAIN, 2009:4).

On average, South African children at national level do not consume recommended daily intake of micronutrients. The average of dietary intake of, calcium, iron, zinc, selenium, vitamins A, B6, C, D, and E, and riboflavin niacin was found to be less than 67 percent of the Recommended Dietary Intake (RDI) (Klugman, 2002:1-2). As Torpy (2004:2) points out, malnourished children have low resistance to illness or have weakened immune systems and therefore are more likely to die as a result of common childhood diseases such as diarrhoea and measles than those who are well nourished.

## 1.6 PREVALENCE OF DIARRHOEA IN SOUTH AFRICA

In a vicious cycle, diarrhoea can aggravate malnutrition and this may predispose the sufferer to diarrhoeal disease (Torpy, 2004:2). Diarrhoea is ranked number

three in the leading causes of death in South Africa, as reflected in an increased number of children, elderly and adults who are dying from the disease. According to the South African child gauge report (2009/2010:31), children die mainly from HIV and AIDS and childhood infections, mainly diarrhoea and lower respiratory infections. A child health identification programme (CHIP) indicated that the vast majority of the 60 percent of children under five who were underweight for age were also HIV-infected. There was a synergy between undernutrition, HIV and diarrhoea (South African child gauge, 2009/2010:31).

A study conducted in KwaZulu-Natal between May 2006 and January 2009 of 1,357 children attending one clinic, found 70 percent complained of a cough, 22 percent skin problems and 19 percent diarrhoea. Some 8.9 percent weighed below the third percentile while eight percent were severely malnourished (Christian, Butler, Vermaak, Rollins, Haskins, Nkosi, Neilands & Qazi, 2011:41).

The Health Systems Trust (2010/11:109) reported that data from the District Health Information System (DHIS) indicated that the national child diarrhoea cases in South Africa generally increased from 186 cases for every thousand children in 2003/04 to 254 in the period 2007/08. Thereafter a dramatic decrease to 109 cases per thousand was seen in 2010/11. The decrease coincided with the introduction of Rotavirus vaccine immunisation in 2008, which increased coverage in 2011. It also coincided with the Blue Drop Certification system by the Department of Water Affairs (DWA), the launch of which encouraged local municipalities to improve their water quality management hygienically (Health Systems Trust, 2010/11:109). It is most likely that the two factors contributed to the decline in diarrhoea cases reported in 2010/11 by DHIS. In KwaZulu-Natal although there was a marked decrease in average incidence from 436.5 cases to 156, the average for the nine districts was still above the national average rate of 109 cases per thousand (Health System Trust, 2010/11:109). For the districts that fall under Integrated Sustainable Rural Development (ISRDP) there was a diarrhoea incidence rate of 113.7 cases, which was slightly above the national average rate of 109.3 cases per thousand children. Among the ISRDP districts the

highest cases were recorded in John Taolo Gaetsewe (Northern Cape), which had 205.9 per thousand. Although the average incidence of diarrhoea for ISRDP districts was 113.7, which is slightly above the national rate of 109.3 cases per thousand, Thabo Mofutsanyane District (Free State) had the lowest average incidence rate of 56.7 cases per thousand, which was lower than the national average of 109.3. It has also been reported that at national level about two thirds of all districts managed to reduce diarrhoea cases by at least half (Health System Trust, 2010/11: 109).

Lack of access to clean sources of water and poor methods of refuse disposal are the major contributors to diarrhoea in South Africa, with about 1.2 million people still lacking access to clean water and twelve million to any form of sanitation (Science Scope, 2009:2). On the other hand, singling out one cause of death in each child is likely to be an over simplification and an oversight, as many deaths may be multifactorial, and even HIV and measles can be complicated by diarrhoea or other infections (Rosenberg, 2007:338).

## **1.7 PROBLEM STATEMENT**

The WHO ranks diarrhoea as the second greatest killer of children below the age of five. As stated above, the level by which diarrhoea contributes to malnutrition is very high (Rajja, 2010:1), and globally diarrhoea is prevalent in developing countries, of which those in Sub-Saharan Africa have the highest prevalence rate. From studies which were conducted in Bangladesh, the Philippines and Uganda, of the children with serious illness requiring admission at hospitals, 50 to 79 percent of measles cases were followed by diarrhoea or pneumonia (Black, Morris, & Bryce, 2003:2232). In the context of South Africa, diarrhoea is a major problem among HIV and AIDS patients, and to a certain extent formula-fed children asymptomatic of HIV and AIDS (Madhi, Cunliffe, Steele, Witte, Kirsten, Louw, Ngwira, Victor, Gillard, Cheuvart, Han & Neuzilk, 2010:290). Undernutrition and HIV infections predispose children to diarrhoea due to a suppressed immune system (South African child gauge, 2009/2010:31). The malnutrition status of



children worsens as a result of each episode of diarrhoea (UNICEF/WHO, 2009:1).

Regular monitoring helps to identify problems early and increases the chance of timely intervention. If malnutrition is eliminated about 32 percent of the global burden of disease would be removed (DoH, 2008:4). In addition, if developmental problems were detected early by health professionals and all other partners involved, there would be a high probability of effectively amending any growth faltering problems (Egal, Sohani & Agoi, 2009:964). Unfortunately, many children visit health professionals only when they are sick, so growth and development may not be the focus of care in many societies, and as such malnutrition may go unnoticed (Escott-Stump & Mahan, 2001:260).

## **1.8 RATIONALE AND MOTIVATION OF STUDY**

This study was the result of a research contract between the Vaal University of Technology, the Centre for Sustainable Livelihoods (CSL) and Feed My Starving Children (FMSC), an international non-governmental organisation (INGO) from the United States of America (USA). FMSC formulated a fortified potato-based food product in response to diarrhoea and as a food product for malnourished children. An agreement between CSL and FMSC was made in which the research project was to document the actual impact of the product on diarrhoea management as well as acceptability of the product. This intervention research project is also the result of collaboration between FMSC, CSL, the community leaders of Qwa-Qwa and the pre-school authorities in Qwa-Qwa, Eatonside and Sharpeville.

The product is fortified with lecithinated soy flour and gum arabic to provide resistant starch, a protein source, and soluble fibre that maintains the gut during diarrhoea and recovery, as well as providing other nutrients (FMSC, 2011/2012:8). According to Mukherjee (2010:1), potatoes are rich in energy and contain not only starch but complex B vitamins, and vitamins C and A. Potatoes also contain micronutrients, mainly phosphorous, iron and calcium, and can also aid in weight gain. While they have various nutritional and health benefits it is important to note

that they are an excellent energy-rich food for those suffering from diarrhoea. Potatoes are easier to digest, facilitate digestion and contain mild roughage, which is recommended in cases of diarrhoea. However, they have to be taken in moderation as excess will cause more diarrhoea as too much is ingested (Williams & Wilkins, 2003:165).

Meanwhile, regarded as one of the most nourishing body building plant foods in the world, soy contains protein which is equivalent to that from meat, milk and eggs. It has all the essential amino acids necessary for human health and growth and is therefore beneficial for growing children and supports growth. It is also very easy to digest (Gibney *et al.*, 2005) and besides proteins it contains vitamins, calcium, folic acid and iron, all of which are essential in child development and growth. These micronutrients are of importance in the proper functioning of the body (William & Wilkins, 2003:165).

On the other hand people are generally careful and cautious when encountering foods for the first time (neophobic), so repeated exposure to and consumption of a range of products in early childhood may play an important part in establishing a varied diet throughout life (Geissler & Powers, 2005:11). When offering a food product to children for the first time it is important to assess the acceptability of the product to aid decisions on whether it should continue to be produced. A range of senses, which includes vision, smell, taste, touch and hearing, contribute to perceptions of the appearance, texture and taste of any new food item. Whether the aspects of food are liked depends on previous experience, expectations or the state of hunger at that particular time. Sensory analysis is about finding answers to particular questions relating to the perception of product quality. The level of a product's acceptability is determined by how individuals perceive its attributes and qualities (Carpenter, Lyon & Hasdell, 2000:24).

The potato-based food product was used in a Qwa-Qwa community as the experimental group and in pre-schools in Eatonside and Sharpeville as the control group. After completion of the six-week intervention study it was given to the

control group for ethical reasons. The results provided documented information to the interested partners to enable them to decide whether to proceed with formulation of the product, and to consolidate their efforts in the provision of supplementary food to address child malnutrition and to mitigate occurrences of diarrhoea in future using locally available similar food formulations or dishes. Despite familiarity with potato-based foods such as mash, the inclusion of soy and other vitamins as ingredients required both acceptability and efficacy tests.

## **1.9 PURPOSE OF THE STUDY**

The purpose of this study was to evaluate the acceptability of a potato-based food product as a nutritional supplement for child growth and as a first food to complement oral rehydration. It aimed to measure effectiveness of efforts to reduce the impact and support the resolution of the symptoms of chronic and acute diarrhoea in children between the ages of two and 13 in a Qwa-Qwa community (the experimental group), and in pre-schools in Eatonside and Sharpeville in Gauteng (the control group).

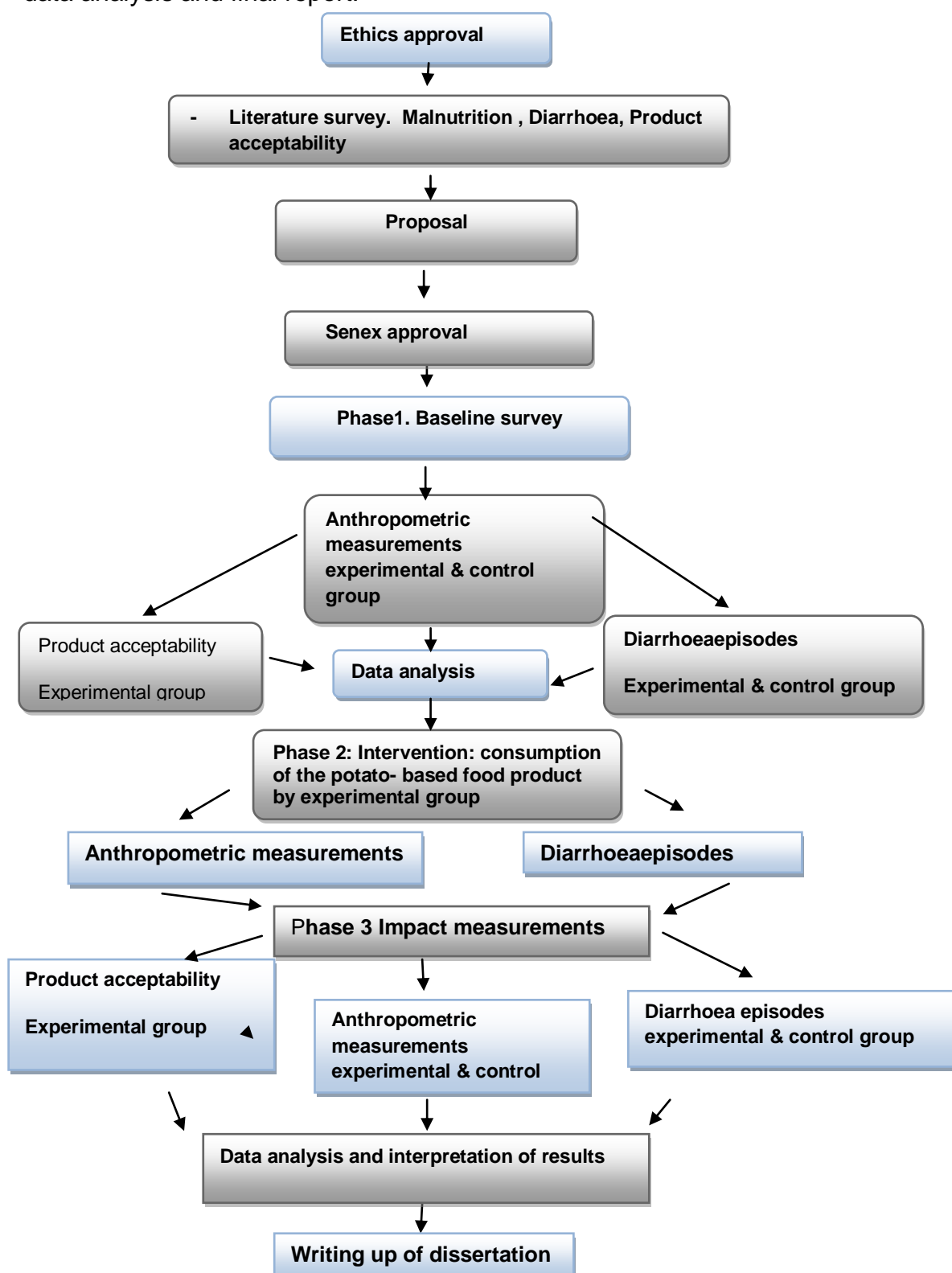
### **1.9.1 Specific objectives**

The specific objectives of this study are to:

- measure the severity and duration of diarrhoea as well as assess the impact of potato-based food product in relieving diarrhoeal episodes
- assess the acceptability of the potato-based food product by children
- assess the impact of the potato-based food product on child growth.

### 1.9.2 Summary of the study

Figure 1.18 indicates the summary of the study from the onset to data collection, data analysis and final report.



**Figure 1.18:** The conceptual framework of the study

## **1.10 OUTLINE OF THE MASTER'S DISSERTATION**

**Chapter 1** has presented a brief introduction to the study, definition, description, causes and consequences of malnutrition and diarrhoea. The prevalence of malnutrition and diarrhoea globally and in South was outlined, followed by the problem statement and motivation for the study. The discussed the synergy between malnutrition and diarrhoea, and outlined the purpose, the objectives and the conceptual framework of the study.

**Chapter 2** reviews the latest and/or most relevant available literature on the description of the strategies to address malnutrition and diarrhoea.

**Chapter 3** presents operational definitions and concepts used in this study, including (a) Child growth patterns; (b) Sensory analyses, with description of, reasons for, and benefits of sensory analyses; and (c) nutritional benefits of soy and potatoes and nutrients found in the potato-based food product used in this study.

**Chapter 4** explains the methods used to collect data in this study. The geographical location of the study is described, notably the set-up of the Save our Souls (SOS) Children's Village.

**Chapter 5** presents the findings and analysis of results obtained in this research project.

**Chapter 6** makes recommendations based on the results of the study and draws a conclusion to it.

## **CHAPTER 2**

### **LITERATURE REVIEW: STRATEGIES TO ADDRESS MALNUTRITION AND DIARRHOEA**

#### **2.1 INTRODUCTION**

The focus in this chapter is on strategies to address malnutrition and diarrhoea, with discussion of various possible interventions that can help address the ailments. At global level, the millennium development goal (MDG) 4 set in 1990 by 189 United Nations member states and adopted in 2000 was based on strategies to address malnutrition. The belief was that if malnutrition was eliminated then an estimated 32 percent of the global burden of disease would be removed (department of Health, 2008:4). In developing countries, child stunting was reduced from 40 to 29 percent during the period 1990 and 2008, while SSA countries reduced child stunting only from 38 to 34 percent, reflecting poor progress in addressing child malnutrition (United Nations Development Programme (UNDP), 2010:1).

Weisstaub, Araya, Hill and Uauy (2008:151) state that although malnutrition can be prevented, a full commitment at the societal level to assigning priority to wellbeing of children is fundamental. Above all, UNICEF (2008:29) recommends the integration of primary healthcare and household food security to effectively prevent it.

#### **2.2 NUTRITION INTERVENTION IN CHILDREN WITH DIARRHOEA**

The WHO (2012c:1) points out that intervention should focus on ways to increase accessibility of adequate and appropriate food by societies which are economically disadvantaged and improve the health system, nutrition and health education, water and sanitation. Appropriate food provision alone should not be targeted in isolation, but should accompany the above factors in unison (Vorster,

2010:6). Vorster (2010:6) further suggests that interventions should allow families and communities to escape the vicious cycle of poverty and malnutrition, which can be achieved if the intervention programmes take a holistic, multisectoral and integrated approach by simultaneously addressing the basic, immediate and underlying causes of malnutrition, of which diarrhoea is one.

Brazil is a good example of a country in which addressing underlying determinants of malnutrition accompanied by political leadership and investments can eradicate or reverse malnutrition and the resultant scourge of diarrhoeal diseases. Malnutrition was reduced by about 50 percent between 1996 and 2006, a fact attributed to four factors, with respective percentages in parenthesis: i) improvement in maternal education (25.7); ii) increased ability of families to buy food (21.7); iii) improved healthcare facilities (11.6); and iv) increased access to proper sanitation (4.3).

Although some of the cost-effective ways of implementing interventions, for example, iodising all salts, reach the entire population, others need to target those groups that require the interventions most. Defining and identifying the target group helps devise a common denominator which may be used to assess the success of the intervention effort (National Bureau of Asian Research (NRB), 2008:7). There are a number of options available to improve dietary intake in children, which health policymakers can use at national level, each with a varying degree of success (Steyn, Nel & Labadarios, 2008:21).

### **2.2.1 Integrated Nutrition Programme in South Africa**

In 1994, South Africa introduced the Integrated Nutrition Programme (INP) through the Health Sector Strategic Framework (HSSF), under the Department of Health. INP was implemented in order to address malnutrition since it is a major contributor to both child mortality and morbidity, as well as to provide treatment for people with Tuberculosis (TB), HIV and AIDS. The INP targets nutritionally vulnerable communities, groups and individuals with children under five and at-risk

pregnant and lactating women. However, the INP stated that for the programme to succeed all sectors needed to work together (Department of Health, 2008b:1).

The main areas of focus for INP are:

- Maternal nutrition: Enabling exclusive breastfeeding to all mothers until six months of age and continuing breastfeeding thereafter throughout weaning up to 24 months and beyond
- Feeding of young children and infants by promoting optimal growth
- Nutrition of youth and adolescents
- Control of micronutrient nutrition
- Elimination of micronutrient deficiency
- Prevention of increased mortality due to diseases of lifestyle by promoting nutrition, treatment and counselling support which is disease-specific
- Management of food service
- Interventions that are community based: capacitating communities in solving the problems of hunger and malnutrition, promotion of nutrition, education and advocacy, improving community ownership and involvement in nutrition programmes and intersectoral collaboration.

The INP targets communities and groups that are nutritionally vulnerable, including the following:

- Children under six years
- Women who are pregnant and lactating
- Children at primary school from poor families.
- Individuals suffering from lifestyle-related disease (communicable diseases) and chronic diseases, disabled persons and at-risk elderly persons (Department of Health, 2008b:1).



### **2.2.2 Nutrition education programmes**

Weisstaub and co-authors (2008:151) acknowledge the need to educate mothers on growth promotion through provision of appropriate home environment, care and stimulation. In addition, Turyashemerwa, Kikafunda and Agaba (2009:975) point to a need to include sanitation and proper child-feeding practices in educating mothers or caregivers. Consequently, one of the INGOs, Personal Awareness Through Health (PATH) (2012:1) is already involved in training of healthcare workers and community volunteers on nutrition programmes, as well as advocating improved nutrition policies in various countries in which it operates.

### **2.2.3 Food supplementation**

A dietary supplement is a product that contains dietary ingredients with the intention of supplementing a diet (U.S Department of Health and Human services, 2012:1). For a dietary supplement to qualify, it should consist of one or a combination of the following ingredients

- Minerals
- Vitamins
- Amino acids/proteins
- Dietary substances that supplement total dietary intake, such as organ tissues or glandular supplements and enzymes
- Herbs or other botanical plants
- Metabolites, concentrates or extracts which are found in a variety of forms, such as liquids, tablets, capsules, gel caps, soft gels or powders. If they are found in any of the forms the information on the label should not state these supplements as convectional meals or food, or a soul item of a meal. (U.S Department of Health and Human services, 2012:1)

In South Africa, consumers are often misled about supplements due to aggressive marketing, with some manufacturers making claims that are not supported by peer-reviewed evidence. On the other hand there are grey areas in terms of legislation, as there is no clear distinction between regulation of medicines and food supplements (Gabriels, Lambert, Smith & Hiss, 2011:1).

#### **2.2.4 Food fortification**

Fortification is the addition of essential nutrients to achieve levels higher than those naturally found in a food (GAIN, 2012:1). A food fortification programme is a valid use of technology when the diet and available food supplies do not provide adequate nutrients, and is a broader approach that complements other efforts to reduce micronutrient deficiencies (WHO, 2006b:13). Many developed countries have introduced food fortification with micronutrients but the degree of success varies (GAIN, 2012:1). It may benefit the target groups if the correct food items are fortified in correct doses. In South Africa, the Department of Health has made it mandatory to fortify a variety of food items to ensure that micronutrient intake is improved and ensure increase in coverage to a wider target population (Steyn, Nel & Labadarios, 2008:22). However, the results are less than anticipated, notably mandatory iodised salt to eradicate iodine deficiency. On the other hand, folate fortification mixes did eradicate neural tube defects (Health Science, 2008:138).

Foods processed centrally are important vehicles to use and requires food industry support (WHO, 2006b:13). In South Africa the main food items that have been fortified since 2003 include maize meal and wheat flour. The major nutrients include vitamins Bs, riboflavin, vitamin A, thiamine, iron, folic acid, zinc and niacin (Steyn, Nel & Labadarios, 2008:22). Some of the advantages of food fortification are as follows:

- As a strategy for rapid improvement in the micronutrient status of a population on a large scale (WHO, 2006b:13).

- The benefits are large and hence it can be a cost-effective intervention (WHO, 2006b:13). It costs about two percent of the unfortified food (Dary & Mora, 2002:7).
- These types of foods contain added nutrients and ingredients that may promote or support overall health and wellness in a variety of ways across many different body systems including heart, bone, digestive, eye, and brain health; weight management; and increased energy and immune health (Food Insight, 2010:1).
- It is a generally accepted concept (Dary & Mora, 2002:2928S).
- In the long run, salt fortification eliminates goitre (Horton, 2006:1070).

Some fortified formulations may contain milk powder or vegetable oil. For instance, the United Nations World Food Programme (WFP) mainly distributes corn soya blend (CBS), although wheat soya blend (WBS) is also sometimes used. Furthermore, the WFP is working on a pilot project in which powders fortified with micronutrients are being given to the needy to sprinkle on top of food after preparation. However, this strategy only works when the beneficiaries already have food, but it is lacking in essential micronutrients (WFP 2012:1). The WFP also addresses moderate malnutrition by providing ready-to-use foods and foods that have been blended with various nutrients.

#### **2.2.5 Dietary diversification**

Dietary diversification is a strategy that encompasses a variety of approaches to increase availability of and access to foods rich in micronutrients, bioavailability of nutrients, and production of foods rich in micronutrients. This can be achieved through:

- Home garden projects that aim at production of crops rich in vitamins for household consumption. Home gardens help to supplement rural diets that are mainly cereal-based.
- Nutrition education.

- Food preservation, food preparation and cooking methods that preserve micronutrient content (Faber & Wenhold, 2007:397).

School gardening projects are also helpful and if used properly can make a contribution to children's health, as they provide them with vegetables and fruit which are rich in nutrients but may be lacking in their normal diet. They are sustainable in that children are shown how to grow vegetables and ways of preparing and eating them. They teach children to appreciate nutritious home grown vegetables at the same time encouraging their families to grow them, and help children understand what makes a good diet (FAO, 2005.2).

#### **2.2.6 School feeding projects**

Hunger and malnutrition negatively affect education so to address the educational challenges in South African schools the National Schools Nutrition Program (Department of Health, 2008b:14) was introduced by the government in 1994, with the overall aim of improving the nutritional and health status of primary school children. It was also intended to improve school attendance levels and the capacity to learn. The government believed that through such a programme the level or gap between the poor and the more privileged in terms of access to education would be levelled. Although the NSNP is a project that responds to addressing nutritional needs it does not address all problems associated with food insecurity and poor nutrition, but rather is only a small part of the integrated food security strategy for South Africa (Department of Health, 2008b:14).

#### **2.2.7 Management of diarrhoea**

Understanding and being able to identify the causes of diarrhoea is important and helpful as it will help in targeting appropriate treatment and interventions to solve the problem effectively. Diarrhoeal management should focus on prevention of the main dangers that each type of diarrhoea presents. In all diarrhoeal situations, the WHO has over a decade recommended use of oral rehydration salts (ORS), as a first-line measure to prevent dehydration (MOST *et al.*, 2005:3).

While diarrhoeal episodes range from moderate to acute, severity is determined by the host's characteristics, such as age, immune deficiency and ability of the pathogens to manufacture infectious disease in the body (WHO, 2010b:8). Management of diarrhoea is complicated in HIV-infected children because of their suppressed immune system. If infected and uninfected children receive the same treatment, the success rate is higher for those who are not infected with HIV. These children are also at high risk of death from persistent diarrhoea. Malnourished children and those with other infections have increased susceptibility to disease (WHO, 2010:7).

#### 2.2.7.1 Treating diarrhoea

The main methods of combating diarrhoea are:

- Prevention of dehydration

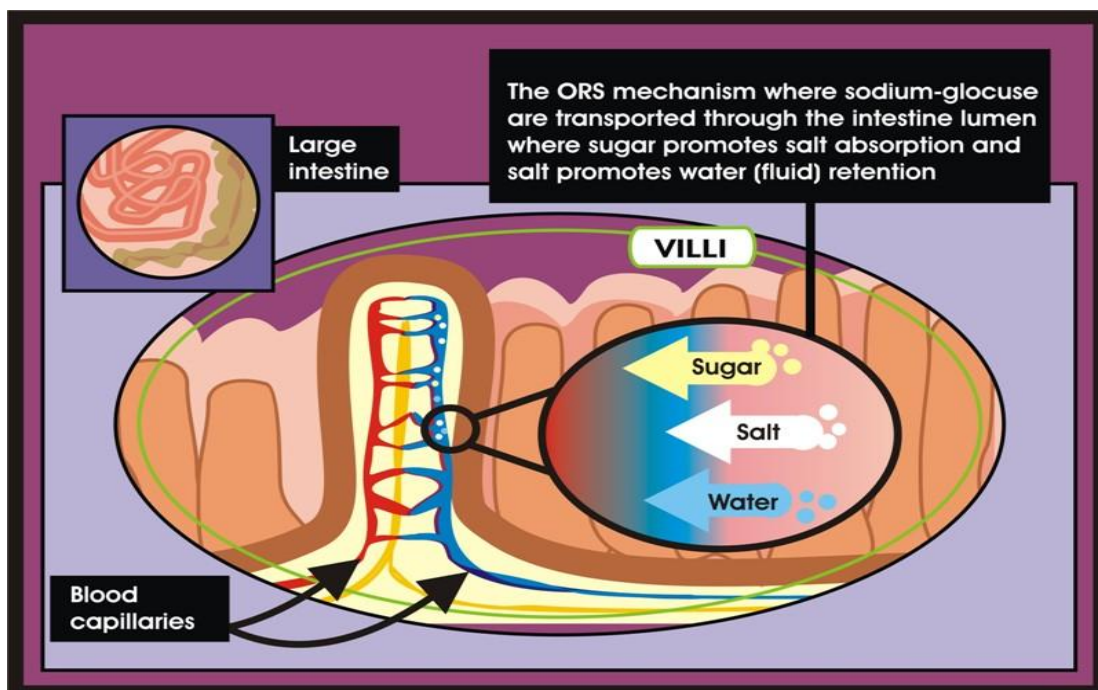
Adequate replacement of water and electrolytes (dietary salt) is important to prevent dehydration. The concentrations and amounts lost through diarrhoea vary. During diarrhoeal episodes 70-110 millilitres of sodium deficit develops for every litre of water lost. Deficit of both potassium and chloride per litre lost is usually in the same range as that of sodium. Such deficit can take place in acute diarrhoeal conditions regardless of the causative agent.

Usually the main pathogenic microorganisms which cause dehydration are Enterotoxigenic *Escherichia coli* (ETEC), Rotavirus and *Vibrio cholera* when there is an outbreak. The extent of dehydration is shown by signs and symptoms that are reflected as a result of the amount of fluid lost. Dehydration may not show any symptom in the early stages but the signs will develop as it increases and becomes visible in severe cases.

First symptoms include thirst, irritable or restless behaviour, increase in body temperature, sunken fontanel and sunken eyes (in infants). The symptoms may include darkened urine, which may be followed by decrease in urine and sweat excretion, unconsciousness, a quick pulse, and low blood pressure. If rehydration

is not stopped quickly death follows (WHO, 2005:4). When a child is dehydrated no tears will show when crying, the child may become weak and the mouth may be very dry. When pinched, the skin may take long to flatten out and remain shrivelled (Thompson & Manore, 2005:107).

Home environment remedies for prevention of dehydration are usually drinking available homemade fluids, such as rice water soup and gruel immediately the diarrhoea starts. The frequency of breastfeeding and feeds should be increased. ORS should be given frequently in small amounts (MOST *et al.*, 2005:3). Figure 2.1 (below) gives an overview of the mechanism of ORS in management of diarrhoea. Sugar promotes absorption of salt whereas salt promotes retention of water in the large intestine (Gerlin, 2006:5). However, if a child is dehydrated it should immediately be taken to a healthcare centre where ORS will be clinically administered orally, nasogastrically or intravenously, depending on the situation (Cooke, 2010:243).



**Figure 2.1:** Mechanisms of ORS (adapted from Gerlin, 2006:45)

- Zinc supplementation

Zinc supplement has been a new addition in the treatment strategy, mainly because in developing countries zinc deficiency is common in young children. Zinc deficiency is associated with impaired water absorption, decreased brush border enzyme activity, impaired electrolyte absorption and impaired cellular and hormonal immunity. Literature indicates that if zinc supplements are used during diarrhoeal episodes the severity and incidence in the following two to three months is reduced. It is therefore important to make use of zinc supplements the moment diarrhoea begins (Cooke, 2010:s543).

- Feeding the child

Continuous feeding, including breastfeeding is recommended, with use of available home fluids with normal feeds being given within four hours in uncomplicated gastroenteritis. However, beverages should have low sugar content. To allow catch-up growth an extra meal per day should be given for at least one week after the diarrhoea has stopped (Crooke, 2010:545).

#### 2.2.7.2 Nutritional intervention

In general, a lactose-free and low-fat diet is recommended in treatment of diarrhoea. A high-fat diet should be avoided at all cost as it may increase the loss of acid in the bile, electrolytes and fluids. In any diarrhoea case, regardless of the cause, fat reduction is recommended in dietary management. The main aim is to make sure that enough nutrition is provided for metabolic needs and relief of symptoms (Anastasi, Capilli, McMahon & Heitkemper, 2006:48).

Benefits derived from improved nutrition during diarrhoeal episodes have long been recognised. Persistent diarrhoea imposes severe and different health disruption; therefore proper nutritional management is important. When devising a nutritional management plan the difficulties of the digestive absorptive process should be taken into consideration. In addition, the need to incorporate other nutrients to improve the nutritive value of the food is also important as this will intern help the re-establishment of a normal physiology of the small intestine.

While it is agreeable that an efficient approach to management of persistent diarrhoea should place more emphasis on nutritional management, at present there seems to be no official protocol. Nor is there an official efficient nutritional approach that has been validated at international level. Various dietary options have been put forward, however there is lack of uniformity and consensus. This is a reflection of a missing link (Mattos, Ribeiro, Mendes, Valois, Mendes & Ribeiro, 2009:467).

On the other hand, there are a wide range of manifestations related to the duration of diarrhoeal episodes. For instance, previous nutritional status may lead to different tolerance patterns of a variety of nutrients, increasing the complexity of deciding an ideal efficient diet which is nutritionally complete. However, a nutritional complete diet which requires little or no manipulation may contribute to standardisation of nutritional management of persistent diarrhoea (Mattos *et al.*, 2009:468). Previous studies on dietary intervention of diarrhoea in HIV patients who were given a diet low in fat, found that low residual liquid diet for a ten days and a total relief of diarrhoea resulted (Anastasi *et al.*, 2006:49).

#### 2.2.7.3 Prevention of diarrhoea

The UNICEF/WHO (2009:2) recommendations on control and prevention of diarrhoea are key to child survival and require a concerted effort. Saving the lives of children from death due to diarrhoea, now and the future, is of great value. Diarrhoea prevention processes can be divided into primary, which reduce disease transmission, and secondary, which focus on reduction of severity:

##### a) Primary

- Promotion of hand washing with clean water and soap, which can reduce incidence by 40 percent.
- Provision of quality of water from the source and sufficient water for household use, adequate preparation and storage of food. Chlorination and



filtration of water at household level and keeping it safe should be adopted. This has been seen to reduce diarrhoeal episodes by 47 percent.

- Proper disposal of waste and avoiding open defecation.

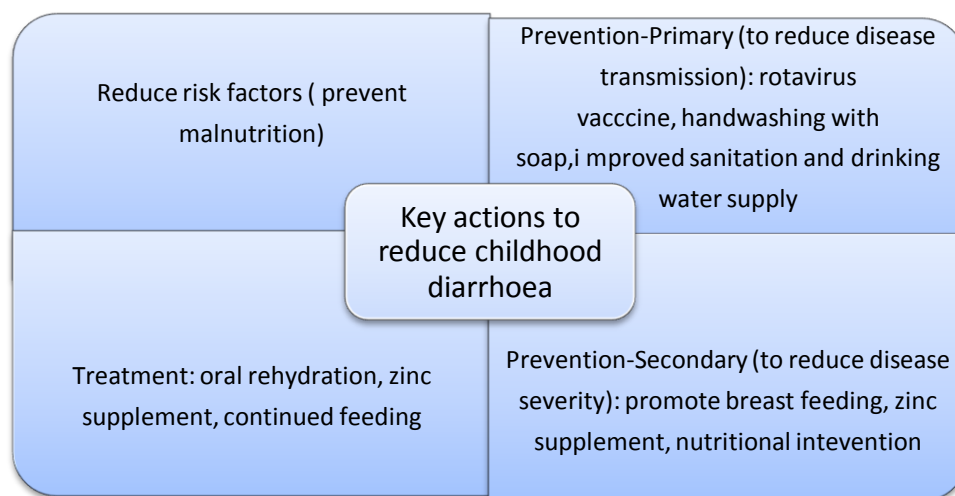
b) Secondary

- Provision of ORS in the management of diarrhoea. In the last 25 years, this has saved lives of more than 50 million children.
- Provision of Rotavirus vaccination in the mainstream of national immunisation vaccination programmes, estimated to be able to save about 600,000 lives per year. Acceleration of availability in Asia and Africa, where the virus is most prevalent is needed.
- Promotion of exclusive breastfeeding.
- Provision of vitamin A (and zinc) supplementation and nutrition intervention.

Usfar, Iswarawanti, Davelyna and Dillon (2010:34) state that washing hands with soap alone can reduce diarrhoeal incidence by 42 to 47 percent, however the strategy depends on the level of knowledge and perception of individuals and availability of clean water. Binns and Lee (2010:270) state that while improved hygiene is also important in diarrhoeal prevention in childcare, improved nutrition has a role in mitigating the burden of diarrhoeal disease.

In addition, UNICEF/WHO (2009:2) emphasise that to prevent and eradicate childhood diarrhoea all stakeholders should embrace the strategies put forward. In order to achieve MDG 4, which aims at two thirds reduction of child mortality, there is a need to emphasise the prevention of diarrhoea and the resultant child mortality and morbidity (WHO, 2009a:3). The WHO acknowledges that there has been an improvement in this regard, although achieving the target is still a milestone to be reached. Effort has to be stepped up in reduction of child death by effectively using the available interventions that are simple and non-expensive, and avail adequate primary healthcare facilities for children up to the age of five

(WHO, 2007b:9). Key actions to be taken are in prevention and treatment of diarrhoea as summarised in Figure 2.2 below (UNICEF/WHO, 2009:2).



**Figure 2.2:** Key factors in prevention and treatment of diarrhoea (adapted from UNICEF/WHO, 2009:2)

## 2.3 CONCLUSION

This chapter has first looked at the global perspective of prevention of malnutrition, the belief being that if it is prevented then the global burden of disease including diarrhoea will be eradicated. The researcher then looked at various interventions used to address malnutrition, including the Integrated Nutrition Programme implemented by the Department of Health in South Africa. This was followed by discussion of various forms of management of diarrhoea, including dietary interventions.

The theoretical concepts and operational definitions will be discussed in the next chapter.

## **CHAPTER 3**

### **THEORETICAL CONCEPTS AND OPERATIONAL DEFINITIONS**

#### **3.1 INTRODUCTION**

The chapter describes children's growth patterns and assessment methods. This is followed by a description of sensory or acceptability evaluation tests and the rationale behind them.

#### **3.2 CHILDREN'S GROWTH PATTERNS**

Gibney and co-authors (2005:378) acknowledge that child growth is characterised not merely by an increase in height and weight, but also by a change of body proportions, reflecting maturation in body composition. Such developmental changes are programmed so that the effects of poor food supply depend to a large extent on the age of the child. Malnutrition in the period of rapid growth may result not only in associated poor cognitive development but also in stunting. According to Klugman (2002:1), anorexia and learning disabilities are also consequences of malnutrition. Learning disability may have lifelong effects. A child growth chart is an indicator of how healthy children are and the wellbeing of a society (Kulaga, Litwin, Tkaczyk, Rozdzyńska, Barwicka, Grajda, Świąder, Gurzkowska, Napieralska & Pan, 2010:1).

Aly, Taj and Ibrahim (2010:90) points out that children form the basis of future societies, therefore they should be given the opportunity to develop fully both physically and psychologically and give a future for human societies. Information and knowledge to guide families on proper parenting in terms of child growth has been made available overtime and the relationships between proper parental caregiving, child health, physical growth and psychological development have become clearer. To promote better psychological development and physical

growth, interventions should also help families to practice responsible parenting, as they have the potential to aid child development (WHO, 2012d:1).

Childhood is a period characterised by active growth in terms of physical, emotional, mental, psychological and sexual development. Major transformation from birth to adulthood progress in a stepwise fashion and depends on adequate nutrition (Mamoun *et al.*, 2005:84). Child development includes growth in terms of height and weight, development of language, brain, emotional wellbeing, temperament and psychomotor skills. Child growth varies and may be influenced by many factors. While one may inherit our body type and potential size from parents, nutrition, lifestyles, good health or sickness also affect growth (WHO, 2007a:1).

Vital development in all domains takes place in the early years of a child's life and they build on each other, with the brain developing much faster. The development of the brain is affected by the environmental conditions, with early undernutrition stress, poor stimulation and interaction having a long lasting effect on the brain structure and cognitive development. As such, the earlier an intervention the better (Grantham-Mcgregor *et al.*, 2007:61).

Child growth is inconsistent but occurs in bursts, the rapid changes for both height and weight taking place within a short period. The first year of life is regarded as a major rapid growth phase in which the birth weight increases by 50 percent, after which it does not double until the age of four. At preschool age, growth is usually slow but can be erratic, depending on the individual, with periods of no growth and followed by growth spurts. The rate of weight increase is usually two to three kilograms per year until the age of nine to ten. The rate then increases, signalling puberty. In terms of height, between the second and fourth year of life growth is on average of seven to ten times. Between the fifth and tenth year growth is between five to ten times per year until puberty (Marian, Williams-Mullen & Bowers, 2007:92).

### **3.2.1 Assessment of children's growth**

Globally accepted standards by the WHO are used to provide the basis for indexing anthropometric measurements (Berry, Hall & Hendricks, 2010:1). Children are constantly growing and changing therefore it is important that a constant periodic assessment be done and problems are identified and addressed early (Brown, Isaacs, Krinke, Murtaugh, Sharbaugh, Stang & Woodidge, 2008:309). An assessment of children's growth includes but is not limited to collection of anthropometric data, such as weight and height. The measurements are used to determine the weight-for-age status, height-for-age status and BMI-for-age by plotting as percentiles on The Centre for Disease Control (CDC) charts, or WHO growth charts (WHO, 2008:1). The growth reference charts are useful when monitoring growth of children and are important to child care, the aim being to see how a child diverges from or matches the international growth references (Kulaga *et al.*, 2010:1).

### **3.2.2 Growth assessment methods**

Growth in children and adolescents is measured using a variety of methods, including the following:

- 1 Anthropometric, which measures stature, that is the child's height (<2 and >2 years), weight and head circumference. This is a common method which is cheap and simple, however accuracy depends on use of the correct tools, such as portable digital scales and stadiometers, and the correct techniques for taking the measurements (WHO, 2007a:1). When taking height measurements the child should not be wearing shoes, have its arms hanging freely to the sides and the whole body, head, buttocks, heels and back positioned vertically against the wall. In terms of weight measurements, the child should wear light clothes, pockets emptied and should stand still with feet apart and flat until the measurements are taken (CDC, 2004:3-22).

- 2 Body composition, which measures the fat and muscle content. This method is more taxing, expensive and complicated, and requires experience. There are a wide range of methods for assessing body composition and their accuracy varies (Mcclanahan, Stocknon, Lanctot, Relyea, Klesges, Slanwson & Schilling, 2009:390). The following methods can be used:
- Total body water measurement, which refers to all water within one's body, including from the urinary tract, in intestines, cells or saliva, and metabolic water.
  - Skinfold measurement, for which the child must be in the correct position. They require skills and experience.
  - Total body electrical conductivity (TOBEC), regarded as a simple, quick and convenient method to assess individual nutritional status. Its principle is based on the fact that fat tissue has electrical conductivity in comparison to lean tissue.
  - Dual-energy X-ray absorptiometry, which measures lean and fat mass. Its use is limited because it is very expensive and requires a laboratory setting (Mcclanahan *et al.*, 2009:390).
  - Total body potassium, which measures body cell mass (De Lorenzo, Andreo, Serrano, D'Orazio, Cervelli & Volpe, 2003:546).
- 3 With reference to the WHO (2012b:1), body mass index-for-age is the ratio of weight (in kg)/recumbent standing or height (in m<sup>2</sup>). The formula for BMI-for-age is:  $BMI = \text{weight (kgs)}/\text{height (m}^2\text{)}$ .

### **3.3 SENSORY EVALUATION FOR DETERMINING PRODUCT ACCEPTABILITY**

A number of factors are significant in evaluating the acceptability of the product being studied. It is first necessary, however, to define sensory analysis.

### **3.3.1 Definition and description of sensory analysis**

Sensory evaluation involves analysing attributes of a product as they are understood by each of the five human senses, hearing, smell, touch, sight and taste. Assessment of a product attributes can be done through the use of product users or consumers who provide distinct features of a product and give responses (Weijzen, Zandstra, alferi, & Graaf, 2008:34). Human chemical senses act as gatekeepers for food intake, protecting individuals from eating unfit food items or spoiled food, while encouraging them to eat healthy and beneficial food (Tuorila & Monteleone, 2009:55).

From the above definitions it is clear that where sensory analysis is involved the five senses are important in terms of how they perceive the food's attributes. Each sense contributes to a decision on whether the food is likeable or to be rejected. Tuorila and Monteleone (2009:55) further explain that analytical sensory evaluation not only serves to identify perceived sensory attributes but also differences in products.

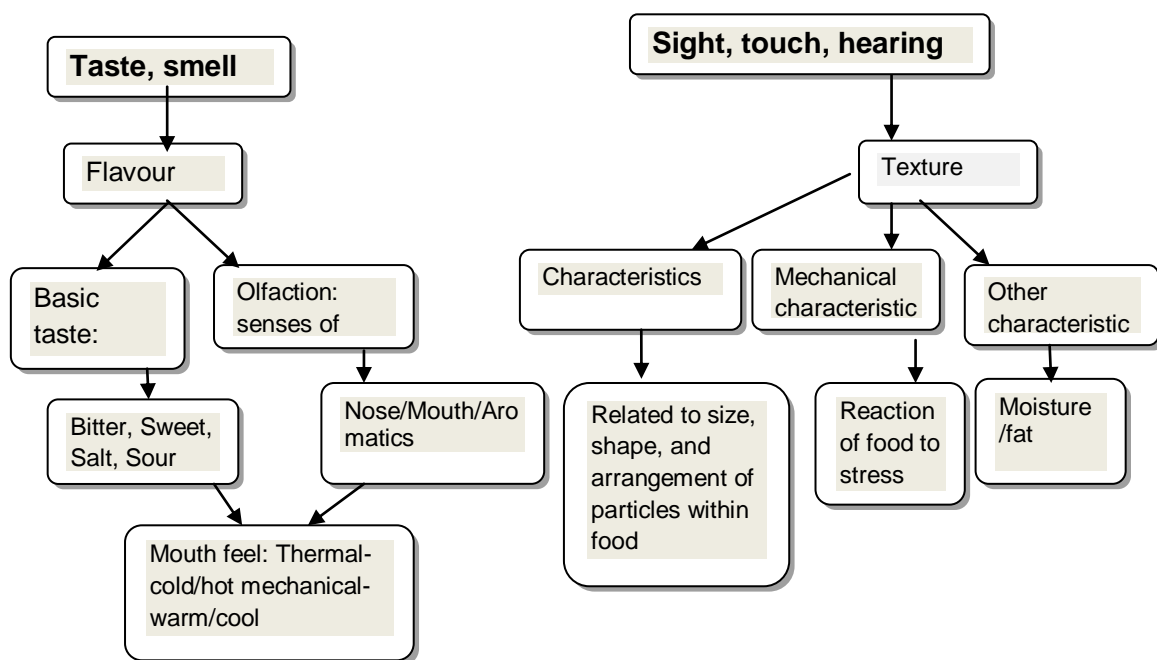
The body (physiology) and the mind (psychology) both play an important role in sensory evaluation process. The physiological relationship is important in analysing food, then the mind manipulates and changes those physiological senses before giving a response. The role of objective sensory analysis is to attempt to measure the physiological stimulus while at the same time keeping the level of bias to a minimum (Carpenter *et al.*, 2000:5).

Although people may have different economical or social status most prefer eating tasty foods in line with or relevant to their own tradition and culture. Any food intervention programme therefore has to recognise food traditions of the environment in which the programme is being implemented (Tuorila & Monteleone, 2009:60). According to Weijzen and co-authors (2008:349), acceptability may rise or fall overtime, but it does not remain stable. Acceptability of familiar food decreases with repeated exposure as a result of boredom or

monotony while that of novel foods increases with continuous exposure. Certain stimuli appear to influence changes in acceptance of food; however it is not yet clear which drive or reduce long-term acceptance (Weijzen *et al.*, 2008:349).

### 3.3.2 The five senses and how they work in food evaluation

Senses interact to give a perception about attributes of a product, the sensitivity of each depending on different types of stimulation (Schifferstein, 2010:1060). In terms of sensory dominance every person uses his or her own ability to sense products differently, depending on which is being interacted with, for instance, whether eating a chocolate, biting a fruit or listening to musical sounds. Therefore, the importance of each sensory modality as perceived by individuals is to a large extent product-specific (Schifferstein, 2005:42).



**Figure 3.1:** Components of the basic five senses (adapted from Sams, 2001:76)

#### 3.3.2.1 Taste and Aroma

Figure 3.1 (above) indicates how the five senses work. The senses of taste and



smell are interrelated and assess flavour (Sams, 2001:76), which according to Smith and Margolskee (2009:1) is a result of a combination of sensory input of smell, taste and the feeling obtained as food is chewed, referred to as 'mouth-feel' by scientists. During heating and chewing, food produces small molecules called 'volatiles' that react with receptors in the oral and/or nasal cavities. Signals from the receptor are sent to the brain for processing, resulting in responses that indicate whether the sensation was sweet, salt, bitter or sour, thus the four basic tastes, and whether the sensation can be specifically identified as smooth, 'brothy,' fruity or 'chickeny' (Sams, 2001:76). The importance of sensory modality is sequential, with taste coming first followed by the sense of smell and then sight (Schifferstein, 2005:42).

Van Kleef, Van Trijp, Van Den Borne and Zondervan (2011:14) point out that food choice or preference is often driven by taste and the likability is a reflection of the pleasure derived from consuming it and its palatability. Van Kleef and co-authors (2011:14) further explain that palatability stimulates appetite and increases product consumption, conversely, those with little nutritional value are often believed to taste better than healthy food. This can be a drawback when introducing new healthy foods, though may be countered by use of different flavours (Van Kleef *et al.*, 2011:15).

The four basic receptors of taste are on the tongue and other surfaces of the oral cavity, with receptors for volatiles located in the nasal cavity. Volatiles collect using the sniffing technique and are forced into the receptors in the nasal cavity for processing and identification (Sams, 2001:76). The mouth and throat are connected to the nose, so the sense of taste is influenced by that of smell. Besides just giving flavour the sense of smell also acts as a gatekeeper so that one is forewarned of things that are 'off' or may cause food poisoning, for example the odour from rotten products. (Silverstein, Silverstein, & Silverstein, 2002:10).

#### 3.3.2.2 Sight, touch, and hearing

Three senses related to the structure and state of product components are hearing, sight, and touch. The sense of sight evaluates sensory attributes of colour and appearance, and light waves stimulate receptors in the eyes, causing signals to be sent to the brain for processing. Therefore, colour and appearance of foods involve the eyes as the sense organ of the body and the components of the object (food) that transmit light (Sams, 2001:76).

An alternative account regards vision as a dominant sensory modality, because it plays an important part in daily activities of human lives. This school of thought identifies vision as the most essential sensory modality because on average a wide variety of products are judged using vision, although its importance may be lower in some products (Schifferstein, 2005:42).

The appearance of a product may influence the perception of the flavours and textural characteristics. In many cases, for example, a mere sight of yellow creamy ice cream may suggest a rich creamy flavour. Sight helps to measure sensory properties such as visual texture, size and shape. Colour differences between products require accurate vision (Carpenter *et al.*, 2000:14). Francis (1995:149) asserts that the first impression of a product is a result of its appearance, and depending on what it is, the colour has to be within an expected range for it to be accepted.

#### 3.3.2.3 Sense of smell

Sense of smell provides very important input to sensory analysis, detecting many different odours when sniffed through the nose. Volatiles given off by food items in the mouth can also be detected by sense of smell, however, perception may be affected by an individual's health condition, such as asthma, pregnancy, hay fever, hunger, mood, flu and menstrual cycle. The location may also affect perception of

odour or smell in the area where food is being tested. On the other hand, volatility is also affected by temperature, therefore it is important to taste food at the exact temperature at which it is served. Humid conditions also affect perception of odours; hence the place should be humid free (Carpenter *et al.*, 2000:14).

#### 3.3.2.4 Texture

For one to enjoy food, texture plays an important role and aids general acceptance of it. Consumers have their own expectations about food, for example in terms of standard and texture. Many consumers use texture to assess freshness and quality of food, as a reason for liking or not liking a food product, although the main sensory feature for liking a product is flavour. Textural characteristics perceived by the sense of sight include coarseness, smoothness and bumpiness. The physical characteristics of texture are the geometrical and mechanical characteristics that are related to structure. These include size, strength, shape, and type of components perceived as the product breaks down due to force applied when biting or chewing. The other characteristics, such as greasy, oily, wet or dry relate to mouth-feel and the sense of touch. The sense of hearing can also evaluate texture, as with crunchiness (Sams, 2001:76).

#### 3.3.3 Reasons for carrying out sensory analysis

Sensory analysis answers questions about product quality, relating to description, discrimination and preference. It is a broad concept the application of which includes acceptability, formulation and reformulation, matching, taints potential, specification, shelf-life testing, quality control and product positioning or mapping (Carpenter *et al.*, 2000:1). On the other hand, in food production organisations sensory evaluation can be useful in meeting research goals (Tuorila & Monteleone, 2009:1).

#### 3.3.3.1 Product Mapping

Market mapping based on sensory profiles of a range of products in the market place is also known as 'product mapping,' and helps to identify product position relative to competitor products. It may also identify visible gaps filled by new product development. There is a stage in the product lifecycle of most products when it becomes necessary to contrast and compare the sensory attributes of a range of related products. Sensory analysis using descriptive techniques in profiling a product is a better method for gathering raw data (Carpenter *et al.*, 2000:5).

#### 3.3.3.2 Product acceptability

Product acceptability is researched with consumers who are a representative of the intended product users. The questions asked on acceptability are not analytical but have to do with consumer judgement, which should be measured via descriptive sensory analysis (Carpenter *et al.*, 2000:11).

#### 3.3.3.3 Product specification and quality

Product specification contains characteristics such as labelling, colour, requirements and standards, and will cover sensory aspects to a greater extent depending on the product. Quality is referred to as a collection of product attributes and characteristics that have the ability to meet the implied or stated needs of consumers. The definition has two parts: objective, which refers to objective sensory aspects of a product and thus the collection of features; and subjective perception of the end user, which deals with satisfying the consumers' stated or implied needs (Carpenter *et al.*, 2000:2).

#### 3.3.3.4 Shelf life studies

Sensory analysis is also used in studying the length of time a product can be stored before there is an unacceptable deterioration in sensory quality. It is important for a manufacturing company to ensure that the consumers receive products in satisfactory condition, taking into account the normal distribution period and retail purposes (Carpenter *et al.*, 2000:5).

#### 3.3.3.5 Taint Potential

Sensory analysis is also used to investigate taint potential of a product, where taint refers to odours or flavours foreign to a food product which may be caused by contact or exposure. Any taint is unpleasant and may result in consumer complaints or loss of repeat purchases, and pose a health risk. In this regard sensory analysis is a useful tool in establishing taint potentials or evidence that helps identify the nature of the taint component, thereby determining the associated hazard, if any (Carpenter *et al.*, 2000:5).

#### 3.3.3.6 Product matching

Sensory analysis can also be used to track sensory characteristics of a product in developing changes that aim to bring it in line with sensory characteristics of a competitor's product. Product matching is two fold, as a result of the marketing department trying to match an own brand with that of a leading competitor, or by the production department requiring help in order to replicate pilot plant quality (Carpenter *et al.*, 2000:7).

#### 3.3.3.7 Product reformulation

Sensory analysis can also be used to provide objective tools for product reformulation. Each alteration of elements of a product or production process

requires impact assessment. At some stage of a product life cycle every company engages in product reformulation. Modern legislation may prompt companies who claim to use original recipes to reformulate their product. On the other hand, the original ingredients for the recipe may not be found on the market and hence product reformulation will automatically take place (Carpenter *et al.*, 2000:8).

### **3.4 FACTORS THAT INFLUENCE FOOD CHOICE AND ACCEPTABILITY**

The choice and acceptability of food may be influenced by the following:

- The genetic constitution of an individual, physiology and age.
- Individual or family eating habits and past food experience (Harris, 2008:315).
- Cultural beliefs, where in some food items are taboo, or social and demographic factors (Xazela, Muchenje & Marume, 2011:12674).
- Negative attitude of adults towards new food, which may influence other children not to try it (Department of Health, 2012:1).
- The environment in which food is consumed, which affects acceptability when served in an institutional setting and rated low in comparison to that served in a restaurant (King, Meiselman, Hottenstein, Work, Cronk, 2005:63).

### **3.5. BENEFITS OF INGREDIENTS USED IN THE PRODUCT IMPLEMENTED IN THIS STUDY**

Focusing on the product currently being studied for this research, the following are benefits of the ingredients.

#### **3.5.1 Nutritional benefits of potatoes**

Lister and Munro (2000:7) state that the nutritional value of potatoes has been

underestimated. Very often it is believed to be high in energy with few other nutrients. Conversely, potatoes contain more nutrients and less energy. Besides being a good source of energy, they contain the following:

- Vitamin C and B vitamins.
- Minerals such as iron and potassium.
- Compounds such as phenolics that have a protective role against coronary heart disease or stroke.
- Although they are fat-free they can easily be converted into fatty acids.
- The energy density is fairly low and provides a small amount of stored energy, though they are filling.
- The quality of proteins is high, although they lack essential amino acids.
- A high moisture content, hence a low impact on blood glucose levels.

The vitamin B6 contained in potatoes, also known as pyridoxine, plays an important role in aiding proper functioning of the central nervous system, normal brain function and normal sleep, as well as elevating mood through its ability to assist the body in making norepinephrine and serotonin hormones. Vitamin B6 contributes to the control of the homocysteine level in the blood, which leads to increased cardiovascular health. Vitamin B6 aids absorption of vitamin B12, which plays an important role in production of immune system cells and red blood cells. In addition, potassium in potatoes is even higher than that found in bananas (Neil, 2009:1).

Potatoes help the body fight disease, containing flavonoids which protect against lung and prostate cancers and help in maintaining a healthy heart (Ledesma, 2009:5). They also contain quercetin, which may boost immunity, and the help maintain healthy blood pressure as they are loaded with kukoamines, plant chemicals which are very good in lowering blood pressure. On the other hand, a green potato tuber contains an undesirable anti-nutritional compound, glycoalkaloids, which has a detrimental effect, albeit minimal, on human health (Lister & Munro, 2000:7).

One way to improve the nutritional value of food is to modify the starch component, hence many potato products are modified to improve their nutritional qualities. Soya is one of the ingredients added to potatoes to boost nutritional value. Resistant starch, a component of food that acts as a pre-biotic to help gut bacteria normalisation and production of chain fatty acids, helps to stimulate and maintain the intestinal surface and ensure proper continued absorption of nutrients and diarrhoea reduction (Neil, 2009:1).

### **3.5.2 Nutritional benefits of dietary fibre**

Dietary fibre is found in plant portions that are indigestible by human enzymes, such as lignin and polysaccharides, oligosaccharides such as resistant starches, and insulin. Dietary fibre is classified as soluble and insoluble. Soluble dietary fibre is fermented in the colon and includes pectin, gums and polysaccharides, whilst insoluble fibre is the bulk, forming parts such as cellulose, hemicelluloses and lignin, and is fermented to a limited extent in the colon (Anderson, Baird, Davis Jr, Ferreri, Knudtson, Koraym, Waters & Williams, 2009:188; Kaczmarczyk, Miller & Freund, 2012:1059). Dietary fibre significantly lowers the chance of coronary heart disease (CHD), and people with high intake of dietary fibre are at a lower risk of peripheral vascular disease, stroke, diabetes, hypertension, dyslipidemia and obesity (Anderson *et al.*, 2009:189). It also plays in protecting against large intestinal cancer by preventing cancer-causing substances from accumulating, since it shortens waste material retention time (Department of Health, 2011:2).

In a study in the USA involving people aged 50 to 70, dietary fibre was seen to reduce the mortality rate from respiratory and infectious diseases. In another study, involving pregnant women, it was associated with the reduction of preeclampsia. It is also associated with increased alertness, cognition and positive mood increase (Kaczmarczyk, Miller & Freund, 2012:1059). Anderson and co-authors (2009:188) state that supplementation of dietary fibre contributes significantly to weight loss, whilst gastrointestinal disorders are prevented by including a fibre in the diet. Such gastrointestinal disorders include duodenal



ulcers, haemorrhoids and diverticulitis disease, whereas probiotics fibres have a role in enhancing immune function. It is further stated that the benefits of dietary intake are similar for both children and adults, and it is recommended that the consumption of dietary fibre should be 14g/4186,8kJ.

Dietary fibre's role in the large intestine relieves and prevents constipation by increasing the bulkiness of the stool and initiating its movement, as well as lubricating the large intestines and making it easier to defecate. Furthermore, it is stated that dietary fibre helps in the process of digestion and absorption of food through stimulation of secretion of digestive fluids and action of bacteria, which is referred to as 'good' in the intestines, resulting in stimulation of vitamin B<sub>2</sub> formation (Department of Health, 2011:2). Soluble fibre helps to relief diarrhoea symptoms, such as frequency of stool, by binding water to making it firm and delay passing.

### **3.5.3 Nutritional benefits of soy**

According to Friedman and Brandon (2001:1078), soy has a number of health benefits. Besides provision of proteins, it can

- lower plasma cholesterol
- prevent diabetes, cancer and obesity
- protect against bowel and kidney disease
- provide essential amino acids.

Soy is a very good food as it is low in saturated fat, contains complete protein, minerals, and can be a good source of fibre (Schardt, 2009:12). It can replace animal protein in the diet (Smolin & Grosvenor, 2008:116). According to Schardt (2009:12), eating at least 20 grams of soy per day is said to significantly lower cholesterol in the bloodstream. It is further stated that soy lowers the risk of blood pressure, triglycerides and cancer. The health benefits has been recognised by the Department of Health in the USA, where it is used as a meat substitute in school lunch programmes (Moon, Balasubramanian, Rimal, 2011:480).

A study involving six to ten year old children who consumed soy showed a reduction in plasma triglycerides and very low density lipoprotein cholesterol. It was encouraging that the health benefits of lowering hypercholesterolemia was good, since hypercholesterolemia was rising among children (Chapman, 2004:14). According to Rah, Hasler, Painter and Chapman-Novakofski (2004: 238), consumption of soy has increased due to the health benefits regarding women's health that include reduction of osteoporosis and menopausal symptoms. Addition of soy to foods reduces fat and energy content and increases functionality (Wenrich & Cason, 2004:140).

According to the United Soybean Board (USB, 2012:1), soy is also rich in vitamins and minerals such as folate and potassium. In addition, soy in children's diet eases constipation, strengthens bones, combats diarrhoea, helps with appetite and weight control and may decrease risk of breast cancer later in life (Chapman, 2004:11). Roday (2008:161) writes that soy prevents the growth of cancer cells, whilst Chapman (2004:11) notes that children with food intolerance and allergies, or who for religious reasons do not eat meat or drink dairy milk, can benefit from eating soy products as they also contain calcium and vitamin D, and high quality protein.

In a study of Nigerian children with diarrhoea and malnutrition, soymilk and soybeans were shown to cause a decrease in duration of diarrhoea and stimulated weight gain, while the total duration of diarrhoea was high in infants fed with cows' milk. It was also stated that bone mineralisation and metabolism of vitamin D is higher as compared to infants fed on cows' milk and breast milk (Chapman, 2004:13).

Roday (2008:161) asserts that soya milk is cholesterol-free and has twice the protein quantity as cows' milk. In addition, soya contains isoflavones which retard aging, facilitate calcium absorption, reduce LDL cholesterol levels and raise HDL cholesterol. This may be due to the amino acid composition of soy or may be related to the phytoestrogens in soy (Smolin & Grosvenor, 2008:166). Soya can

indirectly improve bone health. The isoflavone genistein contained in soya also inhibits breakdown of bone, thereby maintaining bone tissue (Soya-food South Africa, 2009:1).

In South Africa, soy-based products are becoming increasingly popular lifestyle products, with more people are now choosing to eat soy instead of meat or including soy protein in their diet owing to awareness of the potential benefits to be derived (Rolando, 2012:1). Adding soy protein to corn meal, breads, any traditional food or pasta, is an efficient and low-cost way to ensure adequate protein for vulnerable populations (Soya-food South Africa, 2009:2). In this study soy was the main source of protein required for keeping a healthy gut and for stimulating and maintaining the intestinal surface.

#### **3.5.4 Benefits of sodium**

Sodium is one of the important elements needed for proper functioning of the body. It is critically required for proper functioning of nerves as it stimulates muscle contraction and is used for regulation of blood volume and pressure. It also helps to keep minerals such as calcium soluble in the body as well as adrenalin stimulation. In addition, it works together with bicarbonate and chloride to maintain a negative and positive balance of ions in body tissue and fluids. It has the main extracellular ion that has the capability of holding body tissue water (Obikoya, 2010:1-2). However, sodium should be eaten in moderation as too much consumption may contribute to high blood pressure in some people (Lichtenstein, Appel, Brands, Carnethon, Daniels, Franch, Franklin, Kris-Etherton, Harris, Howard, Karanja, Lefevre, Rudel, Sacks, Van Horn, Winston, Wylie-Rosett, 2006:82; MedlinePlus, 2011:1).

#### **3.5.5 Benefits of vitamin A**

Vitamin A, also referred to as retinol, maintains healthy tissue such as visual purple formation in the retina and a healthy retina which makes one able to see in

dim light. Vitamin A aids growth and health of mucous membrane, teeth and skin. It aids normal development of soft skeleton tissue and teeth (MedlinePlus, 2011:1). Vitamin A was specifically used in this study to assist in maintenance of immune system (WHO/UNICEF, 2004:1).

#### **3.5.6 Benefits of vitamin D**

Vitamin D is soluble in fat but since it is present in very few food items it is usually added, as well as being available as a dietary supplement (National Institute of health, 2010:3). Vitamin D is also produced when the skin is exposed to direct sunlight and triggers vitamin D synthesis. It aids absorption of calcium and maintains concentrations of phosphate, adequate serum calcium, enabling normal bone mineralisation and prevention of hypocalcemic tetany. In addition, vitamin D is required for bone remodelling by osteoclasts and osteoblasts, and for growth and strengthening of the bone. Adequate vitamin D prevents rickets in children and osteoporosis in adults. It also plays an important role in the body by modulating cell growth and reducing inflammation, and is also required for immune and neuromuscular function. Vitamin D partly modulates many genes encoding proteins responsible for regulating cell differentiation, proliferation and apoptosis (National Institute of Health, 2010:1). It is very difficult to obtain adequate vitamin D from natural foods alone, so use of foods fortified with vitamin D is essential to maintain good health.

#### **3.5.7 Benefits of folate**

Folate is also referred to as Vitamin B<sub>9</sub>. Together with vitamins B<sub>12</sub> and B<sub>6</sub> it plays a key role in the conversion of homocysteine into methionine, one of the building blocks with which the body can build new proteins. Research has also revealed that if a pregnant mother receives too little folate it increases the likelihood of having a baby with spinabifida. Studies have revealed that consumption of more than average requirements of levels of folate acid reduces risk of colon cancer (The Nutrition Source, 2012:1-4).

### **3.5.8 Benefits of zinc**

Zinc is often lost in diarrhoea, leading to deficiency, weight loss, impaired immunity and poor growth (Branca & Ferrari 2003:10; WHO/UNICEF, 2004:1). Even if zinc deficiency is mild the growth of a child is affected (Juan, Rivera, Hotz, Gonza' Lez-Cossi'O, Neufeld & Garci'A-Guerra, 2003:4010S).

### **3.6 CONCLUSION**

In this chapter, the researcher covered theoretical concepts and operational definitions of key terms used in this study. These included methods of assessment of children's growth according to WHO standards and description of sensory evaluation for product acceptability. This was followed by discussion of the benefits derived from the ingredients and nutrients found in the potato-based food product which was used in this study.

## **CHAPTER 4**

### **STUDY DESIGN AND METHODS**

#### **4.1 INTRODUCTION**

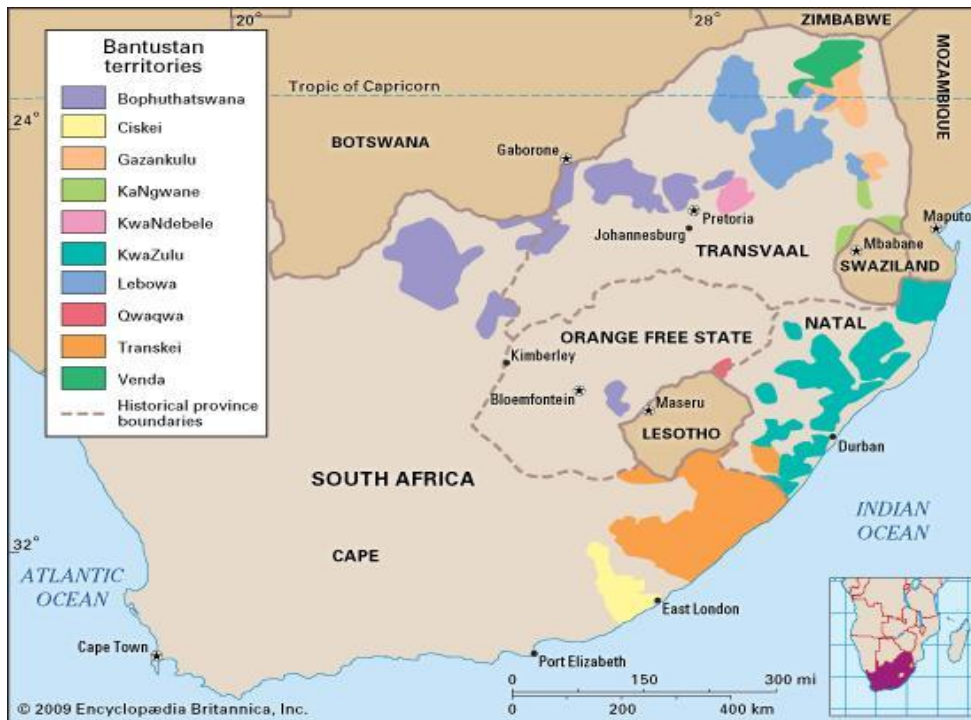
Having outlined the theoretical background, in this chapter the focus is on the description of the methods used to accumulate all the data needed to complete the study, from the planning, ethical approval, sampling, implementation of the intervention study, data collection, data capturing, analysis and interpretation, to the writing of the final report.

#### **4.2 PLANNING AND ADMINISTRATION**

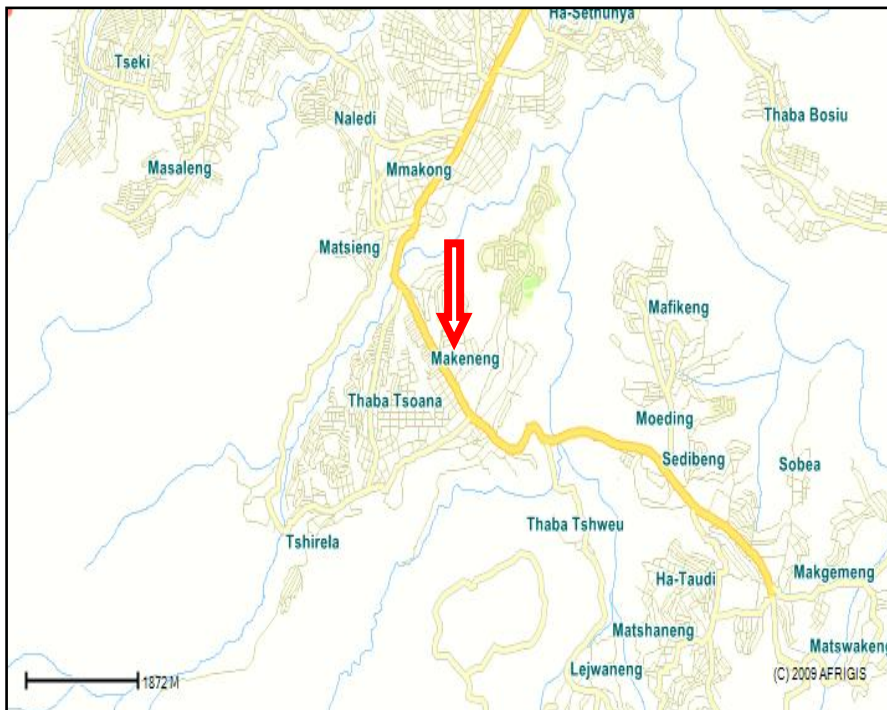
The planning and administration of the study included geographical and ethical considerations.

##### **4.2.1 Geographical demarcations**

Qwa-Qwa is situated on the eastern side of the Free State Province, next to the Lesotho boarder, and falls under Thabo Mofutsanyane District Municipality. Previously known as Witsieshoek. It was occupied by two tribes, namely the Bakoena (1876) and the Batlokoa (1883). It is the smallest former homeland of South Africa in terms of land area and population size. At present it is the home of the Basuto people (Pitso, 2009:1-3). This study was undertaken in one of the Qwa-Qwa SOS villages, situated in Makeneng village. This area was chosen for the study as it is very dry and most of the community members are impoverished (SOS Children's villages South Africa, n.d.).



**Figure 4.1:** Map of South Africa (Qwa-Qwa depicted in red) (Encyclopaedia Britannica, 2009:1)



**Figure 4.2:** Map showing geographical position of Qwa-Qwa SOS Children's Village in Makeneng community



**Figure 4.3:** The site of the SOS Children's Village Makeneng Qwa-Qwa

A charitable organisation, SOS (Save Our Souls) built four houses for orphaned and abandoned children. The houses are integrated into the community and are built to resemble the neighbourhood. Each has a house mother, selected from the local community, who takes care of eight to ten children as a normal family. Since the SOS village is small some of the children are integrated into the community, and these were included in this study.

#### **4.2.2 Ethical considerations**

This study was a contract research project that FMSC asked the Centre of Sustainable Livelihoods to carry out in order to test the actual impact in terms of diarrhoeal relief and possible contrition to nutritional intake, as well as acceptability of the potato-based food product in the targeted orphanage centre. Ethical clearance for the project was obtained from the Human Research Ethics Committee (medical) of the University of the Witwatersrand, Johannesburg (M080931) (Annexure A). In addition to the ethics clearance (M080931), complementary permission was obtained from Chief of Qwa-Qwa community (experimental group) and preschool owners of Eatonside and Sharpeville child care centres (control group) in order to carry out the study. The control groups



were chosen because they have similar characteristics, i.e., low income, Southern Sotho speaking, food insecurity and a high unemployment rate (Oldewage-Theron and co-authors (2006:795). In addition, the control and experimental groups are geographically far apart, thus reducing the possibility of cross-contamination of the results by sharing the food commodity being tested.

An initial meeting was then held with the leaders and caregivers, during which the aims, objectives and significance of the study, as well as the contents of the consent forms and questionnaires, were explained. In accordance with the Helsinki agreement, on commencement of the study, all caregivers signed informed consent forms on behalf of children aged less than seven, while those older signed the consent forms by themselves. All forms were signed voluntarily. Respondents were issued with coded project numbers to mask identity and dissemination of all information was treated with confidentiality. All consent forms and records of coded names were kept in safe place with the project leader at the CSL office. Only coded data collection forms were utilised in the field and data capturing/reporting exercises. The field workers or another researcher, with the exception of the project leader, could not identify respondents' identities. Also, the respondents were reminded that they had the right to answer the question(s) without any leading comments. All technical words were avoided and replaced with simple words that related directly to the questions.

### **4.3 FIELDWORKERS**

Trained fieldworkers were used to collect data using pre-validated questionnaires. Training for the initial implementation of activities and refresher courses was given, including in the administration of all questionnaires, such as sensory evaluation, diarrhoea episodes and methods of filling in anthropometric data questionnaires. The fieldworkers were made aware of the objectives and importance of the project and to overcome bias during translation those able to speak the local language and the same dialect as the children and caregivers were employed. During training the researcher also asked the fieldworkers to practise using the questionnaires, translating from English to Southern Sotho and

vice-versa, to ensure that there was no variation in interpretation of the questionnaires. The questionnaires were also written in plain English with no technical jargon for easy interpretation by fieldworkers (Unite for Sight, 2011:2). The sensory questionnaire had pictures on the main questions so the participants only had to tick the faces which described their perceptions about the product. Monitoring and control measures included training on a regular basis as a way of refreshing the knowledge and skills of research assistants, regular observations during interviews, and regular spot checks by the researcher and supervisors.

#### **4.4 STUDY DESIGN**

An experimental study design was used in which there were two groups: the experimental group consisting of 96 children from the SOS Children's village Makeneng community in Qwa-Qwa, including those children integrated into the community, and the control group consisting of 100 children from Eatonside and Sharpeville childcare centres. An experimental study design is a determinant in finding if the intervention had any causal effect on the experimental group, and whether the findings can be used on the same population from which the sample of the study was taken (NCTI, 2011:1). According to Babbie (2010: 233), use of a control group which does not receive any treatment allows the researcher to see the effects of the experimental stimulus on the experimental group. The study was undertaken in three phases, namely a baseline survey, the intervention study, and the impact measurements.

##### **4.4.1 Phase 1: Baseline survey**

A baseline survey was conducted to gain an overview of the current nutritional status, diarrhoea prevalence and the initial acceptability\sensory level of the potato-based food product which was to be used for this intervention study. This information provided the researcher with the basis on which to compare any changes before the intervention (pre-test measurements) and after the intervention (post-test measurements) and be able to determine if any significant

changes could have been due to the treatment effect of the food product given to the experimental group.

#### 4.4.1.1 Sampling

A purposive sample of (n=100) boys and girls aged two to 13 years from an SOS village in Qwa-Qwa was used as the experimental group because they were the only children enrolled at the orphanage centre. According to Babbie (2010:193), a purposive sample, also referred to as a judgemental sample, is used when non-probability sampling methods cannot be utilised due to field realities. In this instance the researcher uses his/her judgement to select the most useful units to be studied (Welman & Kruger, 2001:63). In this study the researcher could not use probability sampling since the orphanage centre did not constitute a large population (Babbie 2010:192), therefore all children at the SOS orphanage were selected as the whole sampling population for the experimental group. However, on the first day of the intervention four children were missing, thus reducing the baseline experimental group number to 96. Comparatively, 100 children from two pre-schools of Eatonside and Sharpeville in Gauteng were used as a control group. These were all the 50 children (purpose sampling) attending each of the two pre-schools of the control group.

#### 4.4.1.2 Measuring instruments

A questionnaire was used for recording weight, height and diarrhoea episodes (Annexure B) and a hedonic questionnaire (Annexure C) for acceptability tests (sensory analysis).

##### 4.4.1.2.1 Description of the questionnaire for diarrhoea, weight and height and the procedure for administering the questionnaire

The questionnaire was reconstructed by CSL from previously validated questionnaires whereby the respondents' identification and willingness to

participate, diarrhoea, weight and height were recorded. It consisted of three distinct sections A, B, C.

#### Section A: General (on enrolment to the study)

This section was to be completed only on the initial enrolment day. The section also had an option to check if a child was allergic to any of the ingredients used in the potato-based food product. If positive the child would immediately be withdrawn from the study on medical grounds.

#### Section B: Survey

This section was used to record all questions regarding diarrhoea. Each entry was dated. The diarrhoea incidences, episodes, type of diarrhoea (soft, watery or hard), duration and any medication used was to be recorded on this sheet on enrolment and on a weekly basis for six weeks. The same questionnaire for taking height and weight measurements was used for collection of diarrhoea data (Annexure B). On enrolment, respondents with diarrhoea were recorded and thereafter on a weekly basis for six weeks up until on the last day of the study. The diarrhoea episodes and type were recorded on the columns provided.

#### Section C: Measurements

This section was used to record weight and height on enrolment and on weekly bases for six weeks. Every entry on the data collection sheet was dated. The data was then captured on Excel spreadsheets on a weekly basis for six weeks and on the last day of the study period.

#### \*Anthropometric measurements

A calibrated digital scale was used to obtain weight measurements using WHO standards and guidelines. Concomitantly, the height was measured using an upright stadiometer placed against a perpendicular wall.

##### i) Weight

Two senior researchers, a registered dietician (South Africa) and public health nutritionist (USA), and a visiting postgraduate nutrition student (Illinois University, USA) were assigned to take weight measurements of participants to ensure accuracy. Two were weighing the children while one senior researcher did the recording (Annexure B). The sequence of the procedure was as follows:

- The scale was placed on a level uncarpeted surface
- The respondents were weighed with light clothes and pockets with heavy objects emptied.
- The respondents were then allowed to stand on the scale, straight with the face upright facing the fieldworker
- The arms were hanging freely
- The participants had to stand still with feet flat and apart while measurements were recorded on the data collection form, only when it shows weight that does not move
- Where there was need for a second weight the participant would step down and wait for the zero reading.
- If there was a variation of more than 100 grams between the first and the second reading the scale was checked, zeroed and the procedure repeated. The average of the two readings was then recorded.

ii) Height

- Two field senior researchers and a visiting student from Illinois University (USA) were assigned to take height measurements of participants, whilst the other did the recording.
- An upright stadiometer placed against a perpendicular wall was used
- Participants were measured standing against the wall without shoes
- The participants were standing with heels together and the head positioned so that the vision line was at right angles to the body
- The arms were hanging freely by the sides

- The whole body, head, buttocks, heels and back, were positioned vertically against the wall
- A flat headboard with sufficient pressure to compress the hair was put on top of the participant to set the level of the head
- The feet were put together while the measurement was being taken
- The procedure was repeated once and an average of two readings taken if a difference was detected.

#### 4.4.1.2.2 Description of a hedonic sensory analysis questionnaire and the procedure for administering the questionnaire

A hedonic sensory analysis questionnaire was used to assess perceived sensory attributes and acceptability of the product (Annexure C). Hedonic questionnaires make use of ratings which gives the perception of individuals towards different kinds of food items under given conditions. The study used a hedonic questionnaire consisting of Likert scales in which the respondents were able to choose the degree of liking of the product. A Likert scale provides standardised categories of responses (Babbie, 2010:180). In this study the sensory analysis questionnaire consisted of nine questions, within which there was a Likert scale on which the respondents would put an X on the face to reflected their degree of liking of the product in terms of appearance, texture and taste. The scale had five point ratings of like very much, like it, indifferent, dislike and dislike very much. The data on the degree of liking was captured on Excel spreadsheets in respects of the parameters mentioned above. The scale is well understood by many people and hence has no special limitations. The hedonic scale ratings are valid as long as the tests are run properly. In summary, hedonic scale ratings have been used for the following:

- Detection of minor differences in similar foods
- To show or reveal differences in preferences or attitudes towards food
- To show level of acceptance of any food.

Although the scale is widely used, the ratings vary according to the physiological and psychological state of each consumer (Peryams, 1998:10).

The procedure was as follows:

- Two trained fieldworkers were involved to ensure accurate measurements because of the age of the children
- The investigator prepared the mixture according to the manufacturer's instructions, thus mixing in a bowl with boiling water to a soft consistency
- Disposable spoons were used
- One fieldworker gave the porridge while the other looked closely at the face of each participant and recorded the facial expressions
- Further questions relating to the sensory aspects were asked after tasting the product.

The product is a mixture of potato and soy fortified with various nutrients which included: carbohydrates, saturated fat, cholesterol, dietary fibre, sugars, protein, vitamin C, vitamin A, beta carotene, phosphorus, magnesium, calcium, iron, potassium, copper sodium, copperiodine and zinc thiamine niacin vitamin D, vitamin E, riboflavin, folate, vitamin K, vitamin B5, vitamin B12 and vitamin B6 (Annexure D).

The procedure for preparation and administering acceptability test was as follows:

- Two trained fieldworkers were involved to ensure accurate measurements because of the age of the children *vis-à-vis* portion sizes.
- The investigator prepared the mixture according to the manufacturer's instructions, thus mixing in a bowl with boiling water to a soft consistency.
- Disposable spoons were used for testing the prepared mixture.
- One fieldworker gave the porridge while the other looked closely on the face of each participant and noted the facial expressions, followed by the respondent's verbal response to sensory analysis.

- Further questions relating to the sensory aspects were asked after the testing.

#### 4.4.1.3 Data analysis

All the data collected was captured using Excel spreadsheets, including that of sensory acceptance, then analysed using the Statistical Package for Social Sciences (SPSS) version 20.0 for descriptive statistics (frequencies). The respondents' anthropometry was calculated according to WHO growth standards, using AnthroPlus 2007 software (WHO, 2007a). The WHO growth standards were used to make a statistical comparison of the anthropometric indicators. Height and weight measurements were classified according to height-for-age, weight-for-age and BMI-for-age by a statistician using WHO anthroPlus programme version 1.0.02. The following cut-off points were used; z scores -2 and +2 were considered to be normal whereby any score outside this range was abnormal according to standard WHO classifications and classified as follows:

- Wasted (below -2 z-score weight-for-height/height or BMI-for-age)
- Severely wasted (below -3 z-score weight for height)
- Underweight (below -2 z-score weight-for-age)
- Severely underweight (below <-3 z-score weight-for- age)
- Stunted (below -2 z-score height/height-for-age)
- Severely stunted (below -3 z-score height/ height-for-age).
- Overweight (reflected by >+1SD BMI-for-age) (WHO: 2009b:1)

Data on both diarrhoea episodes and sensory analysis was captured on Excel spreadsheets and assessed for frequencies and descriptive statistics using SPSS Version 20.



#### 4.4.1.4 Validity and reliability of the measuring instruments

Validity refers to how well the instrument measures what it is supposed to, whilst reliability refers to the extent to which results are consistent over time and whether they can be replicable under a similar methodology (Golafshani, 2003:599). The questionnaires were validated by FMSC in terms of content and previous studies in Senegal (Taren, Almony, Tecle, Navarette, Ernst, Menrad, Diop & Wele, 2011:4913) and Zimbabwe (unpublished) have used similar questionnaires.

#### 4.4.2 Phase 2: Intervention study

Before the intervention was carried out the product was sent to Minnesota Valley Testing Laboratories (USA) for safety checks. A certificate was issued testifying that it did not contain any harmful substances (Annexure E). After importation to South Africa the product was inspected by Emfuleni Municipality' public health department for admittance to the country.

##### 4.4.2.1 Respondents and sampling

The same children who participated in the baseline survey were used for the intervention study.

##### 4.4.2.2 Procedure for conducting the intervention study

The experimental group (n=96) was given a packet of the cooked product. Although the bag contained twelve servings of 22 grams equivalent to a quarter cup, the caregivers were instructed to double the portion sizes to provide a portion size of 44 grams. In Table 4.1 (below) the breakdown of the nutritional components of the potato-based food product is outlined as found on the label of each bag.

**Table 4.1:** Nutrients and components found in each meal (44g) (Annexure D)

Amount per serving			
One doubled serving= 669,728 kJ		kilo joules from fat = 20,92kJ	
		% Daily values*	
Total fat	1g	1%	
Sodium	180mg	4%	
Total carbohydrates	32g	5%	
Dietary fibre	4g	9%	
Sugars	2g		
Protein	6g		
Vitamin A	6% (RDA)	Vitamin D	20 %
Calcium	6%	Iron	8%
Thiamine	6%	Vitamin E	6%
Niacin	10%	Riboflavin	8%
Folate	15%	Vitamin B6	15%
Zinc	4%	Vitamin B12	15%
*Percent daily values are based on an 8,368,000 joules (8400kJ) diet. Your daily values may be higher or lower depending on your energy needs.			

The procedure of mixing the product was demonstrated to the caregivers, with a portion put in a bowl and mixed thoroughly with boiling water to a soft dropping consistency. The mixture was then spooned to individual serving dishes. This was a similar procedure for mixing and administering product acceptability test to the one conducted for the baseline survey. The control group (n=100) were not given the product, which was incorporated into the children's diet plan and consumed daily throughout the intervention study period at the SOS Children's Village and in their foster care homes.

#### 4.4.2.3 Measuring instruments

The same measuring instruments and methods used in the baseline survey were used during the intervention study for all measurements. These included the weight, height, diarrhoea and sensory evaluation questionnaires.

#### 4.4.3 Phase 3: Impact measurement

On the last day of the six-week period of the study intervention the same anthropometric measurements were taken, a diarrhoea questionnaire administered and the product tested for sensory acceptance by the respondents. Likewise, the same hedonic sensory analysis questionnaire was used to determine perceived sensory attributes and acceptability of the product.

##### 4.4.3.1 Data analysis

After completing the fieldwork, questionnaires were checked for completeness and accuracy. Data was captured on *Excel* spreadsheets. For the experimental group, 93 respondents completed the study ( $n=96-3=93$ ). Two children dropped out and one died during the intervention period. For the control group, 94 respondents completed the study while six were lost at follow-up after six weeks.

For anthropometric measurements, data capturing was followed by inferential t-tests to determine if there were significant differences of weight and height between baseline and final results. The analysed data was presented in tables to aid results reporting.

On diarrhoea, analysed data for baseline survey and the intervention study was displayed in graphs to show the trends and for reporting of results. Paired t-tests were done to determine statistically significant changes on incidence and severity (urgency) amongst the children between baseline and after the intervention.

Regarding sensory analysis, analysed data was displayed on graphs for reporting of results. Paired t-tests were carried out to determine if there was any statistical difference in terms of liking the appearance, taste and texture the product by children between the baseline survey and the end of the six-week study period.

#### **4.5 CONCLUSION**

The chapter has outlined the three phases of the study. The study design and methods used were in accordance with the study design mentioned in Chapter One (Figure1.18, conceptual framework of the study). The results will be discussed in the next chapter.

## CHAPTER 5

### RESULTS AND DISCUSSION

#### 5.1 INTRODUCTION

This chapter will show the results of the two groups of children, namely the experimental group who received the potato-based food product and the control group who were not. A discussion of the results concludes the chapter. The details of planning and administration were covered in Chapter 4, thus only the results will be presented hereafter.

#### 5.2 PHASES 1 & 2: BASELINE SURVEY AND FOLLOW-UP RESULTS FOR EXPERIMENTAL AND CONTROL GROUPS

For Phases 1 & 2, the baseline survey and follow-up results for experimental and control groups were broken down as follows.

##### 5.2.1 Ages of children

**Table 5.1:** Ages of children

Experimental		Control group	
Baseline (n=100)	Follow-up (93)	Baseline (n=100)	Follow-up (n=94)
6.2±3.6	6.4±3.5	3.4±1.2	3.4±1.1

The average age for the children in the experimental group was 6.2 at baseline and 6.4 at follow-up, whereas in the control group the average age at baseline was 3.4 both at baseline and follow-up. At baseline the two study groups experimental and the control group had 96 and 100 children respectively, however, at follow-up the experimental group was reduced to 93 owing to a death

and some not turning up on the last day. The number for the control group fell to 94 when six were lost at follow-up.

## 5.2.2 Anthropometric results

**Table 5.2:** Anthropometric results: underweight (weight-for-age)

		Experimental			Control group		
		Baseline (n=96))	Follow-up (n=93)	Paired t-test <i>p</i>	Baseline (n=100)	Follow-up (n=94)	Paired t-test <i>p</i>
<-3 SD	Severely underweight	4.1(%)	2.8 (%)	0.015	1 (%)	0 (%)	0.004
>-3<-2 SD	Underweight	10.8 (%)	8.5 (%)	0.015	2 (%)	5 (%)	0.004

In Table 5.2 (above) the results for the experimental group indicate that after the intervention there was a reduction (1.8 percent) of severely underweight, while the number of underweight children also decreased (2.3 percent), all of which were statistically significant ( $p=0.05$ ) despite three dropouts. In the control group there was a decrease of one percent of the severely underweight while the number of underweight increased by three percent, and all these changes were statistically significant ( $p=0.05$ ).

**Table 5.3:** Anthropometric results: stunting (height-for-age)

		Experimental Group			Control group		
		Baseline (n=96)	Follow-up (n=93)	Paired t-test <i>p</i>	Baseline (n=100)	Follow-up (n=94)	Paired t-test <i>p</i>
<-3 SD	Severely stunted	4.4%	4.7%	0.000	2.2%	3.3%	0.00
>-3<-2SD	Stunted	11.1%	8.2%	0.000	10.8%	9.8%	0.00

From Table 5.3 (above) it is evident that of the experimental group 4.4 percent were severely stunted at baseline and the number increased to 4.7 percent after the intervention, which was statistically significant ( $p=0.05$ ). In the control group, the number of severely stunted children increased while the number of stunted children decreased relatively by one percent.

**Table 5.4:** Anthropometric results: wasting (BMI-for-age)

		Experimental			Control group		
		Baseline (n=96)	Follow-up (n=93)	Paired t-test <i>p</i>	Baseline (n=100)	Follow-up (n=94)	Paired t-test <i>p</i>
<-3 SD	Severely wasted	2.2 (%)	2.3 (%)	0.022	2.1 (%)	(0%)	0.00
>-3<-2 SD	Wasted	5.4 (%)	6.9 (%)	0.022	3.1 (%)	(3.3%)	0.00

Results from Table 5.4 (above) are somewhat reciprocal between experimental and control groups when it comes to the number of severely wasted children. For instance, the number of severely wasted in the experimental group increased slightly (0.1 percent), while in the control the figure decreased to zero percent. In

contrast, the number of wasted in both the experimental and control group increased.

### 5.2.3 Diarrhoea results

**Table 5.5:**Do you suffer from diarrhoea?

	Experimental group (n=96)	Control group (n=100)
Never	65 (%)	69 (%)
seldom	4 (%)	17 (%)
sometimes	18 (%)	9 (%)
often	8 (%)	4 (%)
always	5 (%)	0 (%)

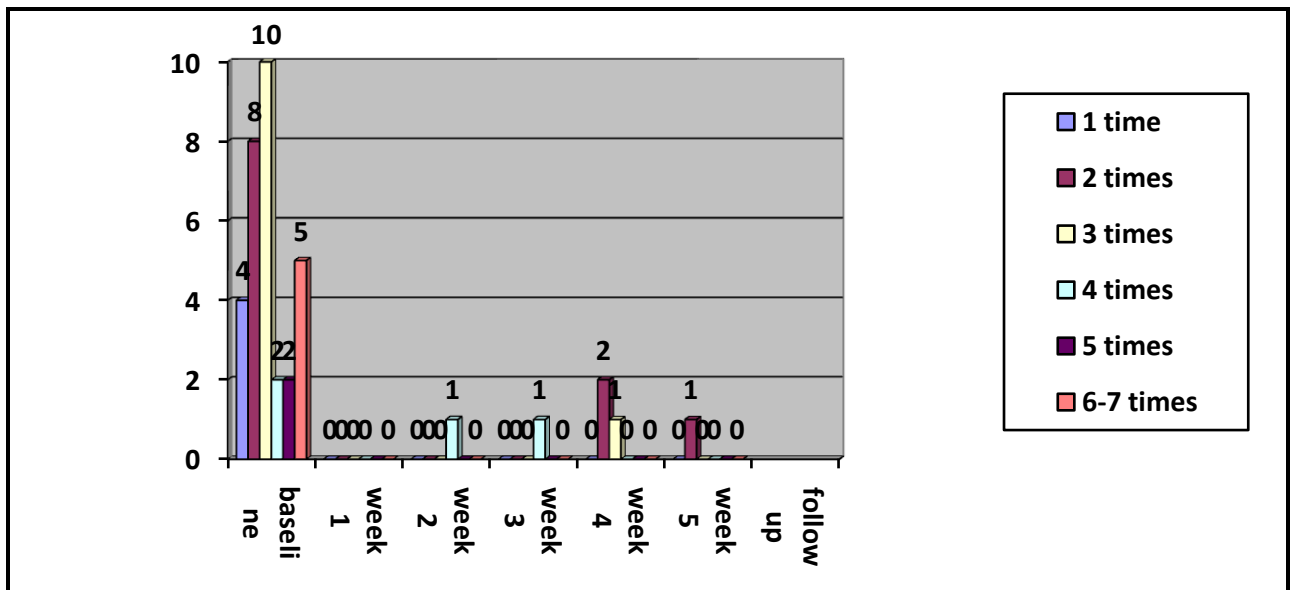
As shown in Table 5.5 (above), both experimental and control groups reported similar diarrhoeal episodes at baseline, but the experimental group seems to have the persistent/chronic incidents as five percent having always suffered.

**Table 5.6:**Did you have diarrhoea yesterday?

	Experimental		Control	
	Baseline (n=96)	Follow-up (n=93)	Baseline (n=100)	Follow-up (n= 94)
yes	32 (%)	None	4 (%)	18.8 (%)
no	68 (%)	None	76 (%)	81.2 (%)

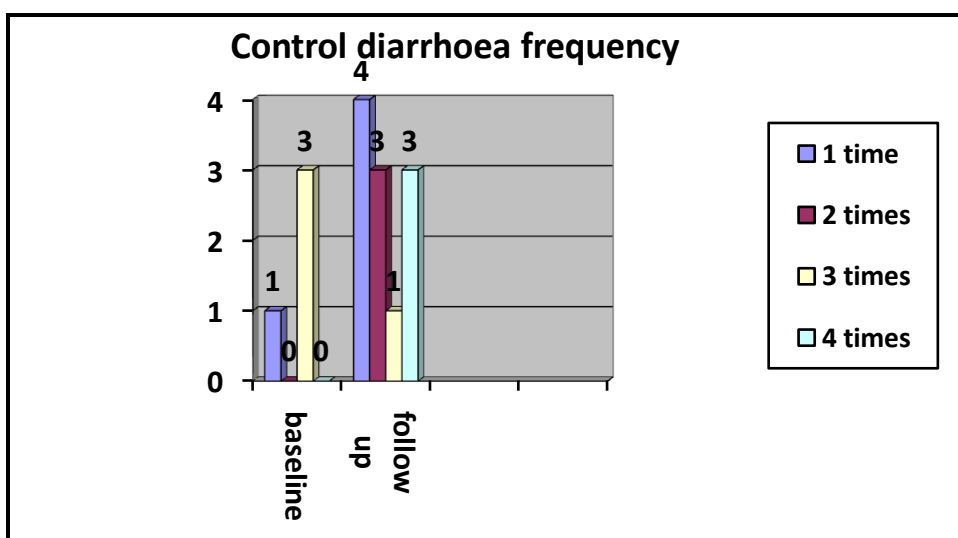
Table 5.6 (above) shows that of the experimental group 32 percent had diarrhoea the day previous day to the survey at baseline, however, after the intervention the same group reported no diarrhoea. With regards to the control group at baseline, four percent of respondents reported having had diarrhoea the previous day and at follow-up. The number of reported diarrhoea cases rose to 18.8 percent, an increase of about 58 percent from the baseline incidences.





**Figure 5.1:** Diarrhoea frequency in the experimental group (n=93)

Figure 5.1 (above) shows the total of children with diarrhoea at baseline was 31 and the frequency ranged from two to ten times in the previous day. As the intervention commenced diarrhoeal episodes were absent in the first week, then rose with lesser incidents and frequency. There was a high noticeable change on the severity of diarrhoea in the experimental group between baseline and follow-up where the paired t-test showed a mean and standard deviation significant difference of  $0.313 \pm 0.455$  ( $n=93$ ,  $p=0.000$ ).



**Figure 5.2:** Diarrhoea frequency in the control group (n=94)

In Figure 5.2 (above), the results indicate only four respondents having had diarrhoeal incidence in the previous day at baseline. At follow-up, diarrhoea persisted not only but increased by 44 percent. This increase from baseline to follow-up was statistically significant with mean and standard deviation of  $0.94 \pm 0.355$  ( $n=94$ ,  $p=006$ ).

**Table 5.7:** Diarrhoea requiring urgent relief

	Experimental		Control group	
	Baseline (n= 96)	Follow-up (n=93)	Baseline (n= 100)	Follow-up (n=94)
	frequencies	frequencies	frequencies	frequencies
none	29	none	1	4
some	2	none	3	3
extreme	None	none	none	2

The results of Table 5.7 (above) at baseline for the experimental group show only two respondents who had some degree of urgency, but at follow-up there were no reported cases of urgency for diarrheal relief. With reference to the figures for the control group, three cases had some urgency at baseline but at follow-up there were four with some urgency and two cases of extreme urgency and that required urgent medical attention at follow-up.

**Table 5.8:** Type of diarrhoea

Type	Experimental		Control	
	Frequencies		Frequencies	
	Baseline (n=96)	Follow-up (n=93)	Baseline (n =100)	Follow-up (n=94)
Fluid only	5	none	3	6
Soft solid	25	none	1	3
Hard solid	1	none		0

In Table 5.8 (above) the experimental group had a total of 30 cases with watery/soft stool at baseline, while on follow-up none was reported. On the contrary, the control group reported four cases of water/soft stool at the baseline while on follow-up after six weeks the number of cases reported increased to nine, an increase of about 56 percent. From these figures it is clear that the experimental group have had more severe episodes of diarrhoea at the baseline which disappeared at follow-up, probably due to the food intervention programme.

**Table 5.9:** Diarrhoea medication

	Experimental		Control group	
	Frequencies		Frequencies	
	Baseline (n= 96)	Follow-up (n=72)	Baseline (n= 100)	Follow up- (n=94)
Yes	22	none	4	8
No	9	none	0	1

According to Table 5.9 (above), in the experimental group 22 respondents who had diarrhoea also used some form of medication to stop it, while nine did not. In the control group only four respondents who had diarrhoea used some medication however at follow-up on the control group eight respondents used medication while only one did not use any. This indicates that the majority (over 50 percent) of the respondents in both experimental and control group opted for medication during diarrhoea at baseline, though the experimental group discontinued at follow-up.

**Table 5.10:** Respondents who took oral fluids

	Experimental		Control group	
	Baseline (n= 96)	Follow-up (n=93)	Baseline (n= 100)	Follow-up (n=94)
Yes	8	none	4	5
No	23	none	0	4

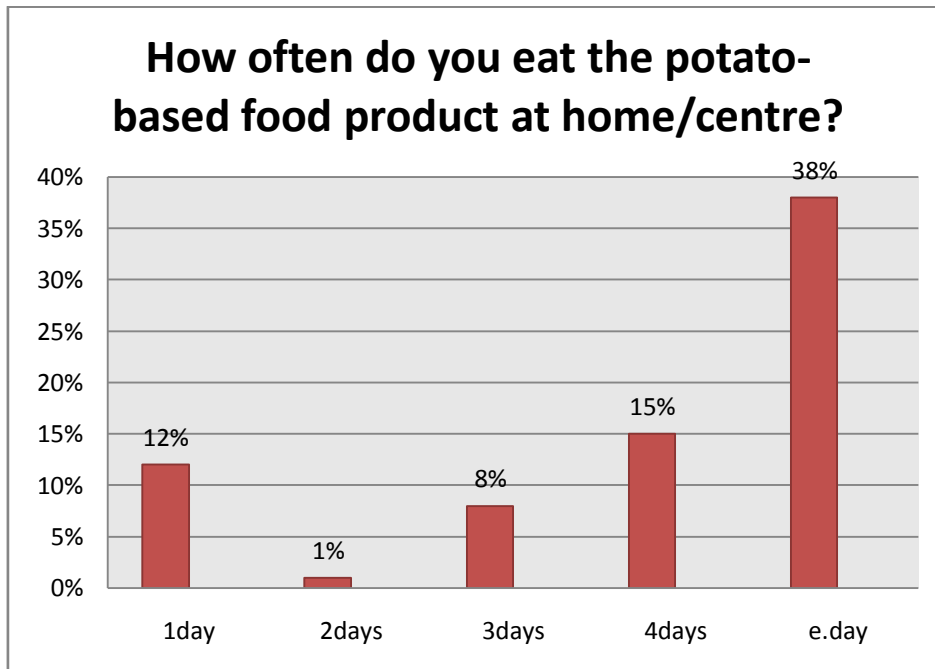
With regards to experimental group at baseline, only eight of the 31 respondents who had diarrhoea used oral fluids for rehydration. With regards to the control group all four respondents who had diarrhoea used oral rehydration while at follow-up five respondents out of the nine who had diarrhoea did so. The results also indicate that the majority of respondents in the experimental group did not use oral fluids during diarrhoeal episodes, whereas the majority of the control group with diarrhoea used oral fluids to control diarrhoea.

**Table 5.11:** Do you have an allergy to soya?

	Experimental (n=96)	Control group (n=100)
Yes	8%	4.1%
No	92%	95.9%

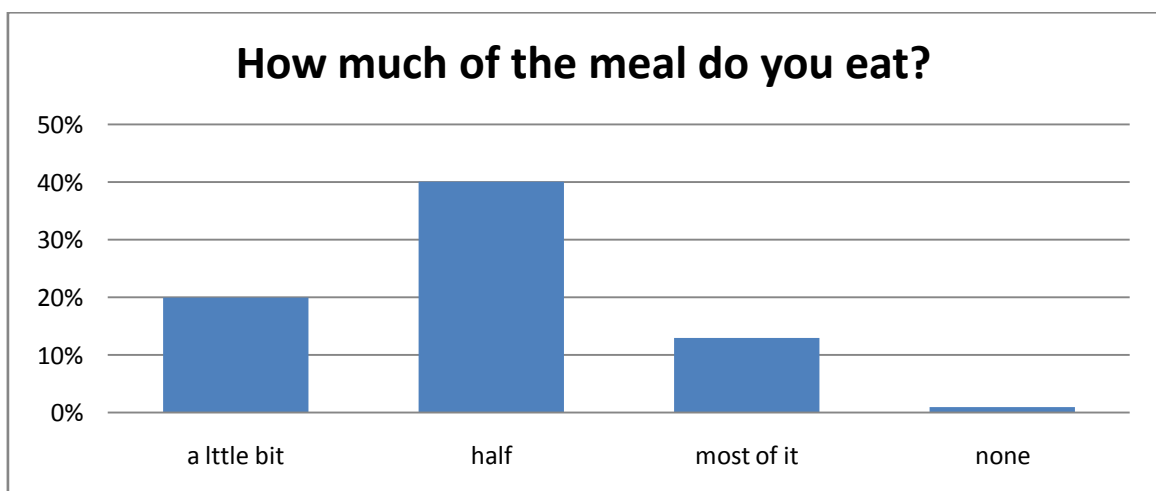
From Table 5.11 (above) only a small percentage of the respondents in both groups indicated having an allergy to soya. The purpose of this question was to explore if the soya in the product could influence the results of this study. The percentage was much lower than that found in the national sensitisation/allergy prevalence studies in South Africa of 12.7 percent (Gray & Kung, 2012:25).

#### 5.2.4: Sensory evaluation results experimental group



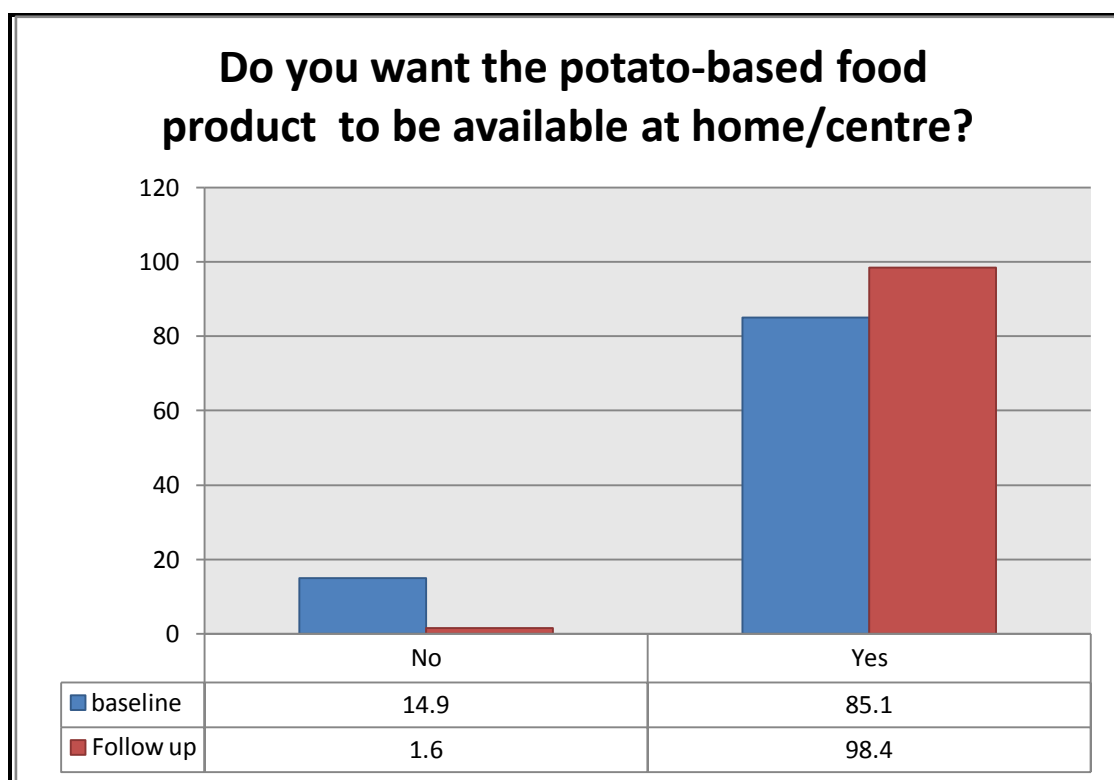
**Figure 5.3a:** How often the product is eaten at home/centre (n=72)

At baseline all subjects were given the product to consume on a daily basis as part of the everyday meal. At follow-up its consumption was not consistent, as reflected by the varying number of days it was consumed. As shown in Figure 5.3a, it transpired that compliance with consumption was compromised, as only 38 percent reported having consumed the product on a daily basis as instructed.



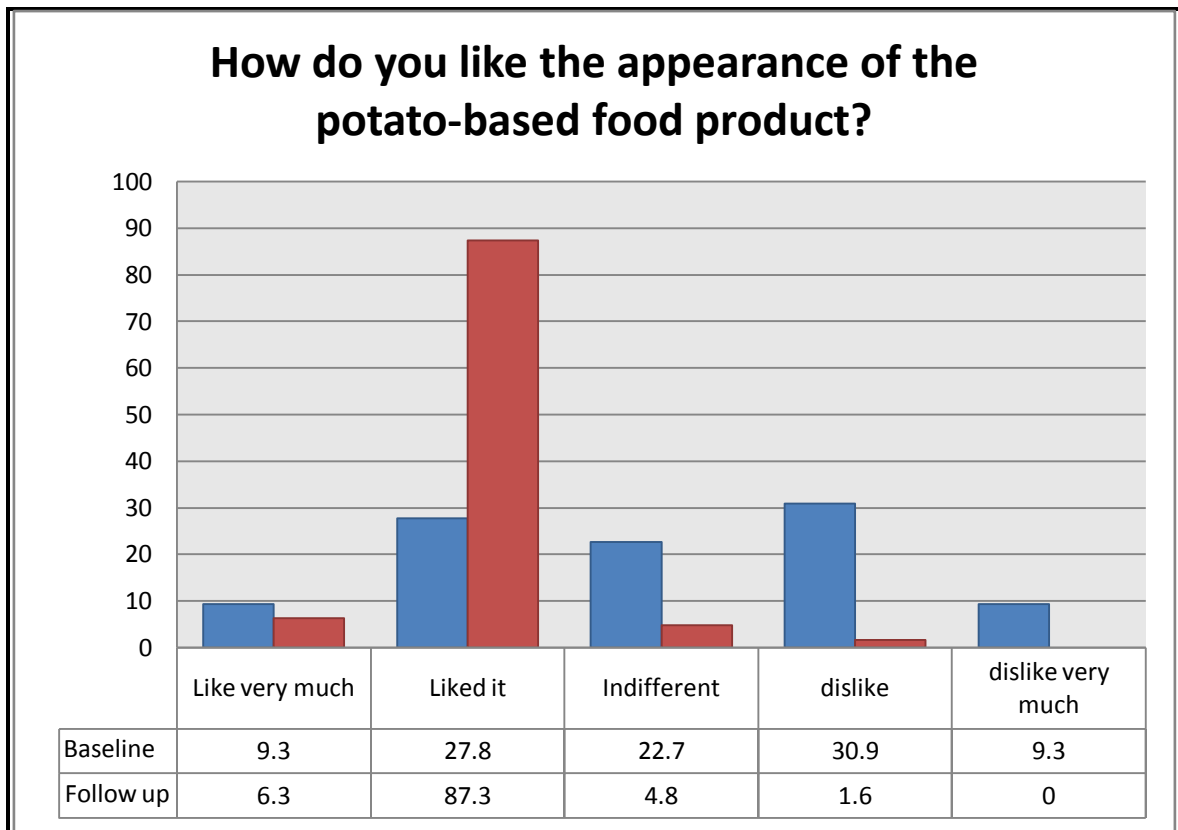
**Figure 5.3b:** Portion size consumed (n=72)

The results from Figure 5.3b give another picture regarding portion size. For instance, only (13 percent) reported having consumed the test meal as instructed, leaving the remaining respondents having either consumed less than half or nothing.



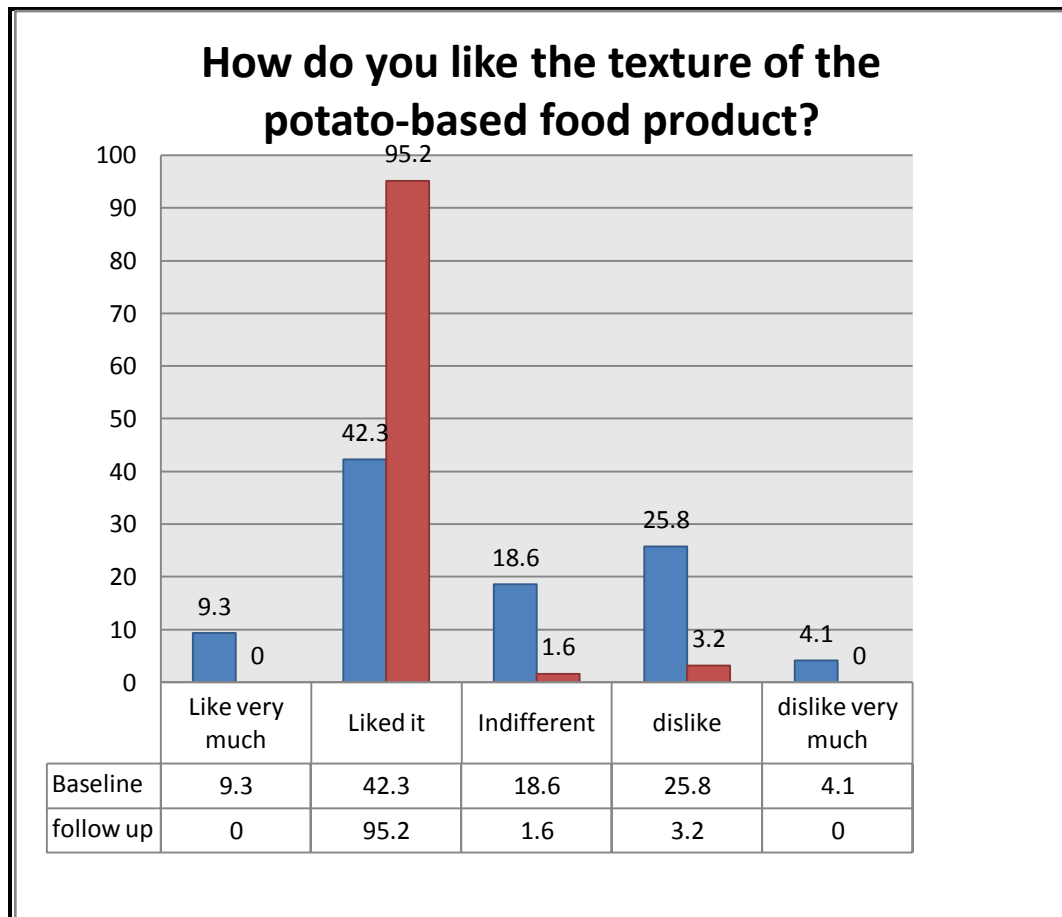
**Figure 5.4:** Availability of the potato-based food product (n=72)

In Figure 5.4 it is indicated that (14.9 percent) of the respondents did not want the product to be at home or at the SOS children's centre, while the majority, (85.1 percent) did. On the final day the number of those who wanted it to be available either at home or at the SOS Children's village grew to (98.4 percent), while only one (1.6 percent) wanted it never to be available in their home meal.



**Figure 5.5:** Liking for the appearance of the product

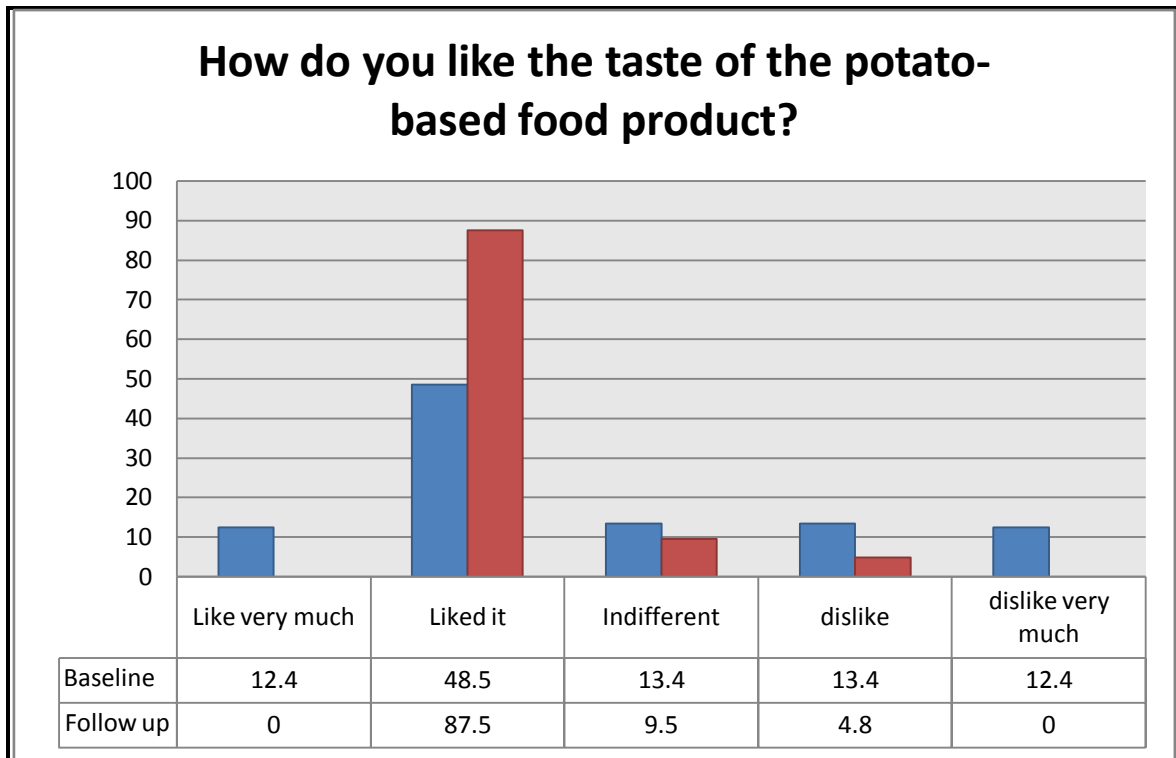
In Figure 5.5 (above) it is indicated that at baseline nearly an equal number disliked very much (9.3 percent) and liked very much (9.3 percent) the appearance of the product where as there was a slight difference on those participants who disliked (30.9 percent) and those who liked (27.8 percent), while the remaining respondents (22.7 percent) were indifferent. At follow-up the number of respondents who liked the product rose to (87.3 percent), while those who were indifferent, who disliked, and disliked very much dwindled to 4.8, 1.6 and zero respectively. The results show that the overall liking of the product interms of appearance by the majority of the respondents was very high (93.6 percent) after using it for six weeks. The significant change between baseline and follow-up was a mean and standard deviation of  $0.968 \pm 1.270$  ( $n=72$ ,  $p=.000$ ).



**Figure 5.6:** Liking for texture of the potato-based food product

In Figure 5.6 (above) at baseline the total number of respondents who liked very much and liked the product texture was (51.6 percent) while this total figure of those who liked very much and liked the texture rose to (95.2 percent) at follow-up. Comparatively, the number of respondents who disliked and disliked very much the product texture totalled (29.9 percent) at baseline but later fell from nearly (30 percent) to little over three percent. The two tailed significant test results showed a high significant change in liking of the product's texture ( $n=72$ ,  $p=000$ ) with a mean and standard deviation of 0.667 and 1.178 respectively.





**Figure 5.7:** Liking for taste of the product

In Figure 5.7 (above) at baseline, the number of respondents who liked the product taste very much and those who only liked the taste of the product was (12.9 percent) and (48.5 percent) respectively. The percentage of indifferent respondents was (13.4 percent) while those who disliked and disliked very much the product taste were (13.4 percent and 12.4 percent) respectively. At follow-up, the overall liking rose to (87.5 percent), the indifferent slightly decreased to (9.5 percent) where as the number of those who overally disked the product taste dwindled to only (4.8 percent). Results reflect that although the taste was acceptable at baseline (48.5 percent), liking of the taste developed favourably as the product was included in the children's diet plan. It might be possible that some of children who disliked the taste of the product might have migrated from those who disliked it and/or were indifferent, which may in part explain how the likeness response increased while the dislike\indifferent one decreased. The two tailed significant tests results showed a high significant change in liking of the product's taste ( $n=72$ ,  $p=.0180$ ) with a mean and standard deviation of 0.413 and 1.352 respectively.

**Table 5.13:** If given this product next time would you eat it?

	<b>Baseline (n=96)</b>	<b>Follow-up (n=72)</b>
No	14.7(%)	1.6 (%)
Yes	85.3(%)	98.4 (%)

In Table 5.13 (above) the majority of the respondents indicated they would eat the product if given it at a later stage, both at baseline (85.3 percent) and at follow-up (98.4). Caution must be exercised, however, in the interpretation of these figures as most respondents would simply accept it if free, as was the case is in this study. If asked to pay for it different results might arise, as compliance was already a major issue, as indicated in the results of Figure 5.3a and 5.3b.

**Table 5.14:** If yes, what is the reason you would continue to use the product?

	<b>Baseline(n=96)</b>	<b>Follow-up(n=72)</b>
Healthy	30.8 (%)	11.1 (%)
Taste	53.3 (%)	82.5 (%)
Stop diarrhoea		3.1 (%)
Stop rash		1.5 (%)

Van Kleef, Van Trijp, Van Den Borne and Zondervan (2011:14) point out that food choice or preference is often driven by taste and the likability is a reflection of the pleasure derived from consuming the food and how palatable it is. In Table 5.14 (above), at baseline 30.8 percent would eat the product if given it next time because it is healthy, while (53.3 percent) stated that their reason for continued eating was the taste. At the follow-up, (11.1 percent) stated that the reason they would continue to eat the product was that it was healthy, while for (82.5 percent) it was the taste. The results reflect that taste was the main driver for continued

eating of the product, as reflected by the increased number of respondents saying so at follow-up.

**Table 5.15:** If no, what do you think can be added for you to like it?

What has to be added	Baseline	Follow-up
milk	1.47 (%)	
Butter + salt	5.88 (%)	1.6 (%)
butter	7.35 (%)	

As follow-up results in Table 5.13 show, (14.7 percent) of respondents indicated that they would not eat the product if given it next time. At baseline, (1.47 percent) would only eat the product if milk was added, (5.9 percent) if butter and salt were added, while (7.4 percent) would eat it if butter was added. As reflected in Table 5.15, at baseline the addition of the stated ingredients would make the product more appealing to (14.7 percent) respondents. However, at follow-up, almost all respondents came around to liking the product without addition of any other ingredient, except for (1.6 percent) who would still not eat it if given next time, unless butter and salt were added.

**Table 5.16:** How easy is the product to prepare?

	Baseline (n=96)	Follow-up (n=72)
Very difficult	0 (%)	0 (%)
Difficult	0 (%)	0 (%)
Easy	8.0 (%)	69.8 (%)
Very easy	92.0 (%)	30.2 (%)

Table 5.16 (above) shows that at baseline, after the researcher had demonstrated how the product was prepared, (100 percent) of caregivers stated that the preparation was easy, and at follow-up the number remained the same. However, the respondents who found the preparation very easy were (92 percent) at baseline and at follow-up down to (30.2 percent). After continued use of the product for six weeks, the results indicate that those who had indicated that preparation was very easy at baseline later viewed the preparation differently, from being very easy to merely easy.

### **5.3 DISCUSSION**

At the time of the intervention study (July 2010), the researcher could not find previous studies in which a potato and soy-based food product had been used either for growth intervention or as an intervention in management of diarrhoea. However, similar interventions have used cereal based food items in child growth intervention studies during and prior to the commencement of this intervention study. This dissertation therefore focuses on the findings of this study, and with limited comparison to few studies on potato-based food products that were published at later dates after July 2010 and up to November 2012.

#### **5.3.1 Anthropometric measurements discussion**

The results from this study indicate that the children in both the experimental and control group were malnourished and to a certain extent living in food insecure households. The total underweight in the experimental group decreased significantly (3.6 percent,  $p=0.015$ ) while the control group increased by (2.0 percent,  $p=0.004$ ). The reduction in underweight observed in the experimental group after the intervention can be a collateral effect due either to normal growth trajectory characteristic to this age group or to reduction of diarrhoeal episodes from the consumption of the potato-based food product, where loss of fluid and nutrients were possibly retained by the body. The latter claim can be supported by the overall increase of underweight children at the follow-up in the control group.

Evidence from the relevant literature that is closely related to this current study revealed that malnutrition is due to poor feeding practices, inadequate food intake, disease and infection, or a multiple of these factors (Lutz & Przytulskik, 2008:6).

Likewise, stunting is a result of chronic poor nutrition (Berry, Hall & Hendricks 2010:1). The intervention was also aimed at improving child growth, however the short duration may not have had a noticeable impact on this, more specifically on the severely stunted and the stunted group. This interesting trend of increasing severity of stunting in the experimental group can be hypothesised to have been caused by:

- a) the dropped out children having been healthier, and so masking the group anthropometrics at baseline. Furthermore, it might be possible that the masked stunted children in the experimental group had been exposed after the dropouts, since stunting could have happened before the age of two, after which it is irreversible (Berry, Hall & Hendricks, 2010:1, Zere & McIntyre 2003:5),
- b) the growth period, specially the height-for-age, being at the critical growth stage for these children and therefore revealing the occulted stunting status at follow-up.
- c) those in the stunted group moving to the severely stunted group.

For the control group the trend was similar to the experimental group, hence the same hypothesis on the fluctuation of the results can be applied to the control group as it could have been affected by dropouts as well.

As expected, both experimental and control groups had gained height significantly during the six weeks intervention periods, as confirmed by the paired t-test of pre- and post-intervention difference. These results were expected in that the children in both groups were in the growing-stage age group (2 to 13 years) (Klugman, 2002:1; Marian, Williams-Mullen & Bowers, 2007:92).

Availability of food can change wasting in different individuals and populations (Faber & Wenhold, 2007:394). Wasting is very useful indicator for evaluating the

effectiveness of any intervention programme since it is sensitive to short-term changes when compared to stunting (Zere & McIntyre, 2003:5). In this study the results did not reflect the effectiveness of the intervention as such, since the wasted children increased in the experimental group (BMI-for-age). The increase in the wasted children can be explained in part due to the dropouts in both experimental and control groups or to gain in height as these children were still in the growing phase of their respective lives. However, the results should be interpreted with caution due to non-compliance by caregivers with regards to consumption patterns, as shown by results in figures 5.3a & b. This could have had a negative impact on the results as there was no consistency in the consumption patterns, with the majority of the children not being given the product every day as was required, coupled with lesser portion sizes and short duration (six weeks only). A study carried out by Royo-Bordonada and co-authors (2003:930) found that school age children of six to seven years showed poor compliance with dietary intakes, which is in agreement with what the researcher found in this study (Royo-Bordonada, Gorgolo, Martin-Moreno, Garces, Rodriguez-Artalejo, Benaventi, Mangas & de Oya, 2003:930). A study carried out by (Taren, Almony, Tecle, Navarette, Ernst, Menrad, Diop & Wele, 2011:4913). found that longer intervention periods, such as four months or more, could result in reduced wasting while using potato-based food products. Comparatively, this study was carried for six weeks only. The lack of weight gain or improvement on wasting in both the experimental and control groups was obtained from the results BMI-for-age indices carried out using WHO AnthroPlus software (Table 5.4).

### **5.3.2 Diarrhoea results discussion**

The potato-based food product was successful in reducing diarrhoeal incidence and frequency in the experimental group. This was evidenced by total absence of diarrhoea immediately after the intervention in the first week and at follow-up, and as indicated by the high significant change ( $n=93$ ,  $p=000$ ) between baseline and follow-up (Table 5.6 and Figure 5.2). However, during the study period there was scattered incidence of diarrhoea which could have been attributed to non-consistency in administration of the product at the orphanage centres by the

caregivers. This was different from the control group, in which the incidence remained largely unchanged with no statistically significant change ( $n=93$ ,  $p=0.63$ ). Furthermore, the use of oral medication evident in both groups may have had an impact on the results.

Evidence from literature suggests that the main aim in diarrhoea management is to ensure that adequate nutrition consumption meets the metabolic needs of such individuals and provides symptomatic relief (Anastasi, Capilli, McMahon, & Heitkemper, 2006:48). This is in agreement with this intervention design, where the dietary relief tool was a food-based approach to address the increased needs for nutrient intakes. Should the intervention period be extended at least to four months the effects of nutrient intake may have been observed, as by then the nutritional deficiencies would have been replete and hence underweight reversed.

In general, regardless of the cause, lactose and low-fat diet is recommended in the treatment of diarrhoea. When devising a nutritional management plan the difficulties of the digestive-absorptive process should be taken into consideration. In addition, the need to incorporate other nutrients to improve the nutritive value of the food is also important, as this will in turn help re-establish normal physiological functions of the small intestine (Mattos, Ribeiro, Mendes & Ribeiro Jr., 2009:467). The potato-based food product used in this intervention has a potato base and is fortified with lecithinated soy flour and gum arabic to provide resistant starch, a protein source, and soluble fibre to maintain the gut during diarrhoea and recovery phases. This has been supported by evidence from the above reviewed literature and that discussed in Chapter Three. The product was also rich in other nutrients and vitamins essential for child growth and wellbeing.

The results of the control group indicate that the respondents had nothing to hold water for the normal absorption to take place in the gut during episodes of diarrhoea. This was confirmed by the type of diarrhoea that was more inclined to fluid type both at baseline and follow-up, whereas with the experimental group the fluid type was only prevalent at baseline with the follow-up period having no cases

of diarrhoea. This improvement seen in the experimental group can be linked to the effectiveness of the consumption of the product, which was designed to hold and aid absorption of water in the gut and thus provide symptomatic relieve.

Although the intervention was effective, the contribution from the use of diarrhoeal medication should also be recognised, as 22 of the 31 respondents who had diarrhoea in the experimental group acknowledged using some medication as well against the prevailing diarrhoea. This was the same with the control group, of whom most who had diarrhoea both at baseline and follow-up also acknowledged the use of anti-diarrhoeal medication.

Interestingly, the use of oral rehydration fluid salts (ORS) in rehydration during diarrhoeal episodes was very low in the experimental group, as compared to the control group. This incidence could be attributed to lack of knowledge on the part of the experimental group caregivers of the importance of using rehydration solutions like ORS to mitigate diarrhoea. Literature reviewed in this study states that over a decade ago the WHO recommended use of ORS solution as a first line measure to prevent dehydration (MOST *et al.*, 2005:3).

### **5.3.3 Sensory acceptance discussion**

The consumption pattern of the potato-based food product reduced in terms of the number of days it was consumed coupled with reduced portion sizes at the orphanage centre and at various households of caregivers. As such, this reduction showed non-compliance on the part of the caregivers; hence this could have affected the results of one of the primary objectives in this study, to measure the impact of the potato-based food product on child growth. One of the factors that could be attributed to the reduction in consumption days could have been the need to conserve the product for future use due to food insecurity in the community.



On the other hand, this non compliance was not reflected in the Likert scale test results of the product by the respondents, but rather the liking of the product increased as the study progressed. The acceptance test showed that the product was highly acceptable by children in all the three aspects of sensory analysis of appearance, texture and taste, with a high significance of acceptances ( $p=000$ ,  $p=000$  and  $p=018$  respectively). This may further reinforce the above connotation of the food product conserved for later use as one of coping strategies of food insecurity prevalent in the experimental group. According to Weijzen and co-authors (2008:349), acceptance of food may change over time, showing either a decrease or an increase in acceptance. The overall liking of the appearance at baseline was very low, however, later on the overall liking sharply increased as found in the Weijzen's study. The percentage of the respondents who were indifferent in terms of appearance dropped sharply at follow-up while the overall disliking of the product dropped sharply as well at follow-up.

The overall liking of texture sharply increased with time, increasing by about 43, 6 percent, while almost 17 percent of the indifferent group also changed, and those who were indifferent came to like the texture as well, resulting in the increased percentage of the overall liking of the texture. While the respondents who liked the taste were already three quarters at baseline survey, the figure rose again with repeated exposure. This was also the same for those who were indifferent at first who came to like the taste, with no one disliking it.

According to Schifferstein (2005:42), where food products are involved, taste is considered the most important sensory entity, generally followed by the smell and the visual appearance entities. Although an alternative account suggests that on average vision is the most important aspects in everyday life, as with the mere sight of a creamy mixture suggesting a rich creamy flavour, appearance may fall below in other products (Schifferstein 2005:42). In this study the higher percentage of those who liked the appearance than taste and texture could be explained by this alternative account, as stated by Schifferstein (2005:42) above.

The reviewed literature in line with this study asserts that people are generally careful and cautious when encountering foods for the first time (neophobic), but repeated exposure may result in increased acceptance and consumption (Geissler & Powers, 2005:11). This may explain why the overall acceptance was low on the baseline survey followed by a steady increase in acceptance with time.

However, acceptance of novel foods may increase with repeated exposure, while acceptance of familiar foods may decrease, as a result of boredom or monotony. Certain stimuli properties of food appear to influence changes in acceptance, however it is not yet clear which stimuli drive or reduce long-term acceptance (Weijzen *et al.*, 2008:349). On the other hand, one of the possible motive for the increased acceptance could be the food insecurity that exists in the community, as can be inferred from the results in Tables 5.13 and 5.14, where the notion of food insecurity become apparent when almost all respondents stated that they would continue to eat the product if given again and the main reason for eating the product shifted more from health reasons to taste at follow-up.

In terms of the preparation procedure all respondents agreed that preparation of the product was easy and this could also have aided the continued overall liking of it. Furthermore, the product is similar to local food of a mashed potato dish.

In this study, although the acceptance of the potato-based food product was high, the results should also be taken with caution as changes may occur over time due to boredom. The study was carried out over a six-week period and the results may not be the same were it to be carried out over a year or more.

## **5.4 Conclusion**

The results of this study revealed that the food intervention of a potato-based food product yielded positive changes to the malnourished and food-insecure children depicted by the reduction of the underweight in the experimental group. In addition, the positive impact of the potato-based food was seen by the total

absence of diarrhoea on the first, second and third weeks, when consumption of it could have been consistent and later dwindled, as seen by the emergency of diarrhoea episodes in some of the subjects on weeks four and five. On the other hand, the results revealed that the intervention food product was generally well accepted by the subjects.

## **CHAPTER 6**

### **CONCLUSION AND RECOMMENDATIONS**

#### **6.1 INTRODUCTION**

In every hour about 300 children die because of malnutrition. Malnutrition is attributable to the underlying cause of about two thirds of the total death of children world over. In every four children globally one is stunted while in developing countries in every three children one is stunted. It therefore means their cognitive development may have been impaired because of malnutrition (Save the Children, 2012:8).

On the other hand more than two million children under five die each year due to diarrhoea and pneumonia. Of such deaths 90 percent is concentrated in Asia and Sub-Sahara Africa. While fewer children are dying now as compared to 20 years ago, due to rapid expansion of basic services and interventions such as immunization, of concern is the low coverage of low-cost interventions against diarrhoea and pneumonia especially among the more vulnerable groups (UNICEF, 2012:2). In a vicious cycle of malnutrition, poverty, household food insecurity and acute diarrhoea can aggravate malnutrition and this may inturn predispose a child to chronic diarrhoea disease (Torpy, 2004:2).

In SA, undernutrition continues to be the major problem facing children mostly in rural areas. The reported malnutrition is caused by poor food intake and increased infections in young children. A study by Oldewage-Theron and co-authors (2006:804) in the Vaal region indicated that in South Africa the underlying cause of malnutrition can be attributable to inadequate care of the vulnerable groups such as the elderly and children, household food insecurity, and insufficient essential services including health, education, housing and environmental sanitation.

According to South African child gauge (2009/2010:31) report, South African children die mainly from HIV and AIDS, childhood infections mainly through diarrhoea and lower respiratory infections. There is a synergy between undernutrition, HIV and diarrhoea. Undernutrition and HIV predispose children to diarrhoea due to suppressed immune system (South African child gauge 2009/2010:31).

The main aim of the study was to evaluate the acceptability of an enriched potato-based food product, both as a means of relieving diarrhoeal episodes and for growth, in children at an orphanage centre in Qwa-Qwa and in pre-schools in Eatonside and Sharpeville as control group. However, for ethical reasons the control group was also provided with the potato-based food product at the end of the study (after six weeks)

## **6.2 SPECIFIC OBJECTIVES**

The specific objectives of this study were to:

- Measure the severity and duration of diarrhoea as well as assess the impact of potato-based product in relieving diarrhoeal episodes.
- Assess the impact of the potato-based product on child growth.
- Assess the acceptability of the potato-based food product to children.

## **6.3 LIMITATIONS**

Although the food intervention programme had a positive impact on the parameters which were under this study the following limitations are drawn:

- Compliances was an issue that influenced the results mostly the measure of wasting as seen in BMI-for-age results. Future studies should use effective tools to counteract possible compliance issues.

- The serving temperature of the food was not assessed due to none availability of warming equipment as this might have had an influence on liking of the potato-based food product in terms of taste. In future it may be necessary to take into consideration the serving temperature so that all the respondents taste food at the same temperature as this might have an influence on the taste modality.
- The duration of the study was short and results could have been different due showing either an increase or reduction in product liking due to boredom and monotonous feeling. The study period was controlled by the main partner involved who wanted results within a short space of time.
- The orphanage centre is small hence cannot accommodate all children. It was therefore difficult to equate consumption of the product as it all depended with each care giver in various homes in which some of the children are integrated. The results could have been different if all children are accommodated at the centre and consuming the product alongside their daily meals.
- It was also unclear whether the information provided or reported about the children from the two preschools used in the control group in terms of prevalence of diarrhoeal incidents was accurate as indicated by the very low numbers of children who had diarrhoea in the control group.
- This study considered the possibility of household insecurity and was not part of tools used.

#### **6.4 MAIN FINDINGS**

The nutritional status of the undernourished children in the experimental group has improved after the intervention. This has been reflected by the high significant change in severe underweight within six weeks period. However there was no effect on the condition of the stunted and wasted children. In contrary in the control group the only positive change was a one percent reduction in severely underweight, 1.2 percent decrease in underweight and 0.2 percent decrease in

wasting which was far less than the changes observed in the experimental group and these changes were not statistically significant.

A marked reduction in diarrhoea incidence and frequency was observed in the experimental group showing a significant change between baseline and follow-up ( $n=93$ ,  $p=0.000$ ). The findings were different from the control group where there was no significant change ( $n=94$ ,  $p=0.063$ ).

The potato-based food product was not well accepted at baseline but acceptance progressed after continued use showing a significant change in acceptance for taste, texture and appearance ( $p=0.0180$ ,  $p=0.000$  and  $p=0.000$  respectively).

## **6.5 Conclusion**

It was also found that the use of the potato-based food product contributed to limited improved nutritional status of the children in the experimental group as there was a reversal from severe underweight, underweight in the experimental group except for wasting, stunting which is not easy to reverse in a short period after the age of two years. The study also found out that potato-based product contributed to reduced incidence and frequency of diarrhoea in the experimental group in comparison to the control group. The study also showed that the acceptance of the potato product by children increased with continued use as a result the product can be used for any similar intervention programme where potato-based foods are already in local dish(es). However the results could have been different if all the caregivers administered the food product on a daily basis with the instructed portion size.

## **6.6 RECOMMENDATIONS**

All recommendations from this study is based solely on the potato-based food product tested in this study and are as follows:-

### **6.6.1 For community interventions**

- The potato-based food product can be used as a relief food for diarrhoea intervention and as a food supplement where child malnutrition is observed. The later can be effective if duration is at least four months daily with proper portion sizes.
- There is need for communities to incorporate potatoes and soy into vegetable gardening programmes and reinforced with nutrition education on the benefits of home gardening approach and its contribution for future sustainability.
- Furthermore, communities can be encouraged to use simple rehydration remedies like eight tea spoons of sugar one tea spoon of salt and one litre of clean and safe water
- In future where a similar intervention can be carried out, there is need to ensure consistency by specifying at what intervals should the potato-based food product should be eaten in the diet plan to ensure the same quantities are served at specific agreed days in order to enhance the impact measurements. In this study although the product was streamlined in the children's diet plan each care giver provided the product at different times and there was no consistency among the care givers with regard to portion sizes

### **6.6.2 Policymakers**

There is need to increase awareness on the use of ORS as a first line measure in diarrhoeal management since the results from the experimental group indicated a degree of lack of awareness in this regard.

### **6.6.3 Further research**

- Further research is required where the same acceptability test are carried out over a longer period to check if continued use of the product will result



in continued liking and use of the product and overall contribution in child growth

- In future such a study should be carried out in a clinical setting as it is easier to monitor the respondents and there is more transparency in terms of diarrhoea incidence and frequency reporting.
- Future research studies should include in the study design with food insecurity measuring tool as this can influence product acceptability scores.

## **6.7 RESEARCH OUTPUT**

Oral presentation at Centre of Sustainable Livelihoods Qwa-Qwa Integrated Nutrition Programme mini symposium (QINP) held on 25 May 2011 at Harrismith Inn, Free State, South Africa.

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ANNEXURE A: Ethical clearance of this project



UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Division of the Deputy Registrar (Research)

**HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)**  
R14/19 Egal

**CLEARANCE CERTIFICATE**

**PROTOCOL NUMBER M08031**

**PROJECT**

Qwa-Qwa Integrated Nutrition Project

**INVESTIGATORS**

Dr AA Egal

**DEPARTMENT**

Ins. of Sustainable Livelihoods

**DATE CONSIDERED**

08.09.26

**DECISION OF THE COMMITTEE\***

Approved unconditionally

Unless otherwise specified this ethical clearance is valid for 5 years and may be renewed upon application.

**DATE** 08.11.05

**CHAIRPERSON**

*[Signature]*  
(Professor P E Cleatus Jones)

\*Guidelines for written 'Informed consent' attached where applicable

cc: Supervisor: Prof W O Theron

**DECLARATION OF INVESTIGATOR(S)**

To be completed in duplicate and ONE COPY returned to the Secretary at Room 10004, 11th floor, Senate House, University.

I/We fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee. I agree to a completion of a yearly progress report.

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQURIES

## ANNEXURE B: Height, weight and diarrhoea questionnaire



### DIARRHOEA STUDY: Data Collection Sheet

Hospital : Intervention Control

Patient Code No: .....

Age/date of birth: .....

Gender Male Female

#### SECTION A: GENERAL (on admission to study)

Do you suffer from diarrhea? (if never or seldom, do not enroll)

Never Seldom Sometimes Often Always

Known/documentred allergy to soya food products? (yes/no) ..... (if yes, do not enroll)

Signed consent received by: ..... Date: .....

Hospital discharge date: .....

#### SECTION B: SURVEY (take on enrolment and then daily after enrolment – use additional sheets as needed)

Date	Diarrhea yesterday? (yes/no)	How many times?	Type? (fluid only, soft solid, hard solid)	Urgency? (none, some, extreme)	Taking anti-diarrhea medication? (yes/no)	Taking oral rehydration fluids? (yes/no)

#### SECTION C: MEASUREMENTS (take on enrolment and then daily after enrolment-use additional sheets as needed)

Date	Height (cm)	Weight (kg)	Right Handgrip (kg)	Left Handgrip (kg)	Skin tenting (seconds)	Nail blanch (seconds)

## ANNEXURE C: Hedonic questionnaire

### Sensory Acceptance Form

Centre/Home : \_\_\_\_\_  
 Date : \_\_\_\_\_  
 Respondent No : \_\_\_\_\_

1. How often do you eat the meal at centre/home?

1 day	2 days	3 days	4 days	Every day
-------	--------	--------	--------	-----------

2. How much of the meal do you usually eat?

All	Most of it	Half	A little bit	None
-----	------------	------	--------------	------

3. Have you gone for a second serving?

Yes	No
-----	----

4. If yes in question 3, how often per week?

Once	Twice	3-4 days	Every day	Never
------	-------	----------	-----------	-------

5. Do you want the porridge to always be available at centre/home?

Yes	No
-----	----

6. Please mark with a cross (X) in the box under the face which best describes how you feel about the **appearance** of the meal.



☐



☐



☐



☐



☐

7. Please mark with a cross (X) in the box under the face which best describes how you feel about the **texture** of the meal.



☐



☐



☐



☐



☐

8. Please mark with a cross (X) in the box under the face which best describes how you feel about the **taste** of the meal.



☐



☐



☐



☐



☐

9. If given this product next time would you eat it?

A) yes ☐ B) no ☐

9a. If yes, what is the reason you would continue to use this food product?

9b. If no, what do you think can be added for you to like it?

10. How easy is the product to prepare?

A) very difficult ☐ B) difficult ☐ C) easy ☐ D) very easy ☐

## ANNEXURE D: Nutrients and components found in each meal

### Nutritional Data

**Product Name:** MannaPack™-Potato  
Fortified Potato and Soy Protein Meal Package  
**Part Number:** FMSC MEAL 02  
**Revision:** 1.0  
**Release Date:** 10/12/2009



Nutrition Facts			
Serving Size: 1/4 cup (22g) (1/2 cup prepared)			
Servings Per Bag: 12			
Servings Per Box: 576			
Amount Per Serving			
Calories 30	Calories from Fat 0		
% Daily Value*			
Total Fat 0.5g	1%		
Saturated Fat 0g	0%		
Trans Fat 0g			
Cholesterol 0mg	0%		
Sodium 90mg	4%		
Total Carbohydrate 16g	5%		
Dietary Fiber 2g	9%		
Sugars 1g			
Protein 3g			
Vitamin A 6%	Vitamin C 0%		
Calcium 6%	Iron 8%		
Vitamin D 20%	Vitamin E 6%		
Thiamin 6%	Riboflavin 6%		
Niacin 10%	Vitamin B6 15%		
Folate 15%	Vitamin B12 15%		
Zinc 4%			
* Percent Daily Values are based on a diet of other people's secrets.			
Values may be higher or lower depending on your estate needs.			
	Calories:	2,000	2,500
Total Fat	Less than	67g	60g
Sat Fat	Less than	24g	7g
Cholesterol	Less than	300mg	300mg
Sodium	Less than	2,400mg	2,400mg
Total Carbohydrate		300g	17g
Dietary Fiber		25g	30g

### Feed My Starving Children

401 93<sup>rd</sup> Ave NW Coon Rapids, MN 55433  
Phone: 763.504.2919 Fax: 763.504.5235 [www.fmsc.org](http://www.fmsc.org)

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## MVTL

1126 N. Front St. - New Ulm, MN 56073 ~ 800-782-3557 ~ Fax 507-359-2890  
141 S. 12th St. - Bismarck, ND 58502 ~ 800-279-6885 ~ Fax 701-258-9724  
51 W. Lincoln Way - Nevada, IA 50201 ~ 800-361-0855 ~ Fax 515-382-3885

MEMBER  
ACTIL

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AN EQUAL OPPORTUNITY EMPLOYER

Page: 1 of 1

Report Date: 12 May 2010

Work Order #: 14933

Account #: 0141106

Date Sampled: 6 May 2017

Time Sampled: 15:02

Date Received: 7 May 2013

Sampled by: L.P.

Date Submitted: 7 May 2010

Project Name: POTATO-D MICRO

Temperature at Receipt AMBIENT

CERTIFICATE OF ANALYSIS	An Received Result	Method	Reference	Test Analyzed
10-667125	100503-C2-03 MANNA PACO POTATO FOOD			
Aerobic Plate Count	15000	CFU/gram	BAM 5th Ed	7 May 10
Coliform Count	< 10	CFU/gram	BAM 5th Ed	7 May 10
Escherichia coli	< 10	CFU/gram	BAM 5th Ed	7 May 10
Mold Count	10	CFU/gram	BAM 5th Ed	7 May 10
Yeast Count	< 10	CFU/gram	BAM 5th Ed	7 May 10
Salmonella (VIDAS)	Negative		AOAC/BAM Method 2004.03	7 May 10
Weight for Salmonella	25	grams		7 May 10
Listeria (VIDAS)	Negative		AOAC/BAM Method 2004.05	7 May 10
Weight for Listeria	25	grams		7 May 10

CFU = Colony Forming Units

Директор: И.С.

Lesaffre

Jessie L. Porter, Microbiology Lab Manager, New Ulm, MN

## ANNEXURE F: Certificate for language editing

### ACKNOWLEDGMENT OF LANGUAGE EDITING

Date: Monday, 26 November 2012

This is to certify that Language Editing has been carried out on the following

Master's Dissertation:

*Evaluation of a potato-based food product for acceptability, growth and diarrheal management in children*

by

**Velonah Guyo**

---

Language Editing was carried out to appropriate academic standards, including syntax, grammar and style.

Andrew Graham (BA, MA dist., PhD, University of Keele, UK)\*

011 475 6724

073 469 5014

[happy4andrew@hotmail.com](mailto:happy4andrew@hotmail.com)



\*Former Tutor in Postgraduate Writing Centre and Managing Editor of ISI Accredited Journal