WEIGHT GAIN IN HOSPITALISED LOW BIRTH WEIGHT (LBW) PREMATURE INFANTS RECEIVING BREAST MILK OR BREAST MILK WITH HUMAN MILK FORTIFIER IN THE NELSON MANDELA BAY HEALTH DISTRICT

Ra-eesa WICOMB

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By

Ra-eesa Wicomb

Student no: 216850878

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Supervisor: Dr L Steenkamp

Co-supervisor: Prof M Williams

NELSON MANDELA UNIVERSITY

DECLARATION BY CANDIDATE

NAME: Ra-eesa Wicomb

STUDENT NUMBER: 216850878

QUALIFICATION: Msc Dietetics

TITLE OF PROJECT:

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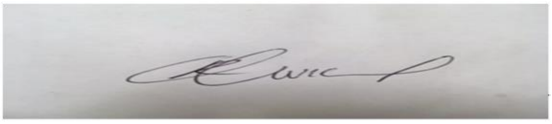

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Abstract

Rationale: Worldwide, hospitals with premature units have one generalised objective, i.e. to achieve postnatal growth and body composition similar to that of a normal foetus of similar gestational age. Optimal nutrition leads to optimal neurodevelopment and breastfeeding (BF) is known as the golden standard for infant nutrition. Human breast milk (BM) has significant value for preterm and term infants and is of special benefit to HIV infected mothers. Maternal supplementation is provided as part of the standard protocol in certain hospitals in the Eastern Cape province to those mothers who breastfeed their low birth weight (LBW) infants after delivery. human milk fortifier (HMF) is a nutritional supplement that is added to expressed breast milk for feeding preterm infants in order to meet their high energy and protein needs and therefore supporting the recommended growth velocity of 10g/kg/day-15g/kg/day. Some hospitals within South Africa provide HMF to preterm infants as part of their standard nutritional protocol in order for the infant to gain weight if BM only failed to produce adequate results. To date, little to no South African studies support or discourage the use of HMF for LBW infants.

Aim: This study aimed to describe the effect of maternal supplementation compared with breast milk with HMF, or a combination of maternal supplementation and breast milk with HMF, on growth velocity in hospitalised LBW premature infants within the Nelson Mandela Bay health district.

Methods: The proposed study design followed a longitudinal, observational, descriptive study in a cohort of LBW infants. The study was analytical using quantitative empirical data. Study participants were selected, by using convenience sampling, at Dora Nginza Hospital, Zwide between October 2015 and August 2016 (ethics approval: EC_2016RP27_564). Quantitative data on anthropometric measurements was collected from study participants. Primary care givers provided written informed consent. Registered nurses were trained and performed anthropometrical measurements according to standardised methods. A structured questionnaire was completed by the principal reasarcher as a source of data collection. Numerical data was described using means and standard deviations. Chi squares were used to describe the associations between maternal risk factors and birth weight outcomes. ANOVA was used to determine the relationship between growth velocity and the various supplementation groups.

Results: A sample size of 91 LBW preterm infants and mother pairs were entered into this study. The majority of mothers, 64% (n=58) fell in the age category of 20-35 years old. Of the total maternal sample (n=88), 35% (n=31) were classified in the at risk age category, i.e. <20years old and >36years old. Out of the total infant sample (n=91), 65% (n=59) was classified as VLBW, 22% was LBW and 22% (n=20) was ELBW. No statistically significant association was found between infant growth velocity and maternal risk factors. The group receiving BM with HMF had a mean growth velocity of 19.75 g/kg/day (SD=6.45) that was statistically significantly (p<0.05) more than the other groups. The maternal supplementation only group and the maternal supplementation and BM fortification group showed mean growth velocities of 12.26 g/kg/day (SD=5.41) and 12.29 g/kg/day (SD=6.97) respectively. A post hoc test was done between growth velocity in the supplementated groups and the length of hospital stay. These results reveal that the group receiving BM with HMF had a significantly (p<0.05) shorter mean length of hospital stay of 11.29 days (SD=7.02), compared with the group on the combination of maternal supplementation and BM with HMF.

Conclusions and recommendations:

In this study, infants receiving HMF with BM showed the highest growth velocity with the shortest hospital stay before discharge. In this group, infants were already receiving an adequate BM intake of 150-180 ml/kg/day prior to participation in the study. This meant that the HMF group consisted of more stable preterm infants compared to the rest of the supplementated groups. However, a large proportion of participants in the maternal supplementation group also showed adequate to good growth velocity. The researcher recommends the implementation of maternal supplementation only, as standard of care for all hospitalised lactating women. Furthermore, timeous addition of HMF to expressed BM is necessary for infants with growth velocities <15 g/kg/day. This may save costs to the hospital as the use of HMF allowed for better weight gain and earlier discharge.

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ABBREVIATIONS

AFASS: affordable, feasable, acceptable, sustainable and safe

AGA: appropriate for gestational age

AIDS: acquired immuno deficiency syndrome

ART: antiretroviral therapy

BF: breastfeeding

BM: breast milk

BMI: body mass index

EC: Eastern Cape

EBF: exclusive breastfeeding

EBM: expressed beast milk

EFF: exclusive formula feeding

ELBW: extremely low birth weight

GOR: gastro-oesophageal reflux

HIV: human immuno deficiency virus

IUGR: intra uterine growth restriction

LBW: low birth weight

NEC: necrotising entero colitis

PMTCT: prevention of mother to child transmission

SGA: small for gestational age

SA: South Africa

VLBW: very low birth weight

WHO: World Health Organization

DEFINITIONS

AIDS: Acquired immune deficiency syndrome; therefore, the HIV-positive person has progressed to active disease (WHO, 2011).

BMI: Body mass index; a number that indicates a person's weight in proportion to height/length, calculated as kg/m^2 (WHO, 2011).

Breastfeeding: Exclusive breastfeeding means giving a baby only breast milk, and no other liquids or solids, not even water. Drops or syrups consisting of vitamins, mineral supplements or medicines (including ORS) are permitted (WHO, 2011).

Breast milk: Milk from the human breast (WHO, 2011)

Calibrate: To check a measuring instrument for accuracy and adjust if necessary and possible (WHO, 2011).

Calories: Kilocalories or calories measure the energy available in food (WHO, 2011).

Catch up growth: An increased growth velocity following a period of growth retardation even if this occurred in utero (Sparks & Cetin, 2006).

Colostrum: The breast milk that women produce in the first few days of after delivery. It is thick and yellowish or clear in colour. It contains more protein than matured milk (WHO, 2011).

Exclusively breastfeeding: An infant receives only breast milk and no other liquids or solids, not even water, with the exception of drops or syrups consisting of vitamins, mineral supplements or medicines (WHO, 2011).

Expressed breast milk (EBM): Milk that has been removed from the breasts manually or by using a pump (WHO, 2011).

Extremely low birth weight: Infants born with birth weights ranging from 500g-1000g (McBride et al., 2015).

Breast milk fortification or human milk fortification: Powder based substance made from cow's milk proteins (intact or hydrolysed). Indicated to be added to human milk with the goal of increasing energy, protein and calcium (WHO, 2016).

Formula: Artificial milks for babies made from a variety of products, including sugar, animal milks, soybean, and vegetable oils. They are usually in powder form, to mix with water (WHO, 2011).

Gestational age: The number of weeks of pregnancy (WHO, 2011).

HIV: Human immunodeficiency virus, which causes AIDS (acquired immune deficiency syndrome) (WHO, 2011).

HIV-positive: Refers to persons who have taken an HIV test, whose results have been confirmed and who know, and/or their parents know, that they tested positive (WHO, 2011).

Infant: A child not more than 12 months of age (WHO, 2011).

Infantometer: A board designed to be placed on a horizontal surface to measure length (lying down) of a child less than 2 year old (WHO, 2011).

Lactation: The process of producing breast milk (WHO, 2011).

Low birth weight: An infant born with a birth weight of 1500g-2500g (Fenton et al., 2013).

Mixed feeding: Feeding both breast milk and other foods or liquids (WHO, 2011).

Nutritional needs: The amounts of nutrients needed by the body for normal function, growth and health (WHO, 2011).

Preterm: Babies born before 37 weeks of gestation (Agostoni, et al., 2010).

Very Low Birth weight: Infants born with birth weights ranging from 1000g-1500g (Agostoni et al., 2010).

CHAPTER 1

BACKGROUND AND MOTIVATION FOR THE STUDY

1.1 INTRODUCTION

Of the low birth weight (LBW) infants born each year, 96.5% are born in developing countries (WHO, 2011). World-wide, complications of preterm births are the main cause of death in children under five years of age and contributed to one million deaths in 2015 (WHO, 2016). Globally, 14.9 million babies were born prematurely in 2010 (Blencowe et al., 2013). The low birth weight rate (LBWR) has been used as a marker for assessing the socio-economic and overall status of women and the surrounding community (UNICEF & WHO, 2004). Statistics of Saving Babies 2010-2011 indicate that the LBWR in South Africa (SA), which is seen as a developing country, is 14.17%. The Province of the Eastern Cape (EC) has a LBWR of 15.51%. The Nelson Mandela Metropole has a LBWR of 17% and it is ranked as the second highest LBWR within the entire EC (Pattinson, 2013).

LBW is viewed as an indicator for predicting infant survival rates and healthy childhood growth and development. This, alternatively, can also be associated with the overall health of the mother prior to, and after, pregnancy. LBW infants is known to contribute significantly/heavily towards neonatal mortality and morbidity, and is therefore known as the single most critical factor associated with neonatal mortality and morbidity (Narain & Prasad, 2014).

In 2009, Statistics SA recorded SA's neonatal mortality rate as 14/1000 live births (Lloyd, 2013). Between 1990 and 2009, lower income countries had the lowest decrease in the neonatal mortality rate compared to higher income countries. Worldwide, ten countries had an improvement in their neonatal mortality rate whilst eight countries had an increase in their neonatal mortality rate. Of these eight countries, five were from Africa with one of them being SA (Velaphi & Rhoda, 2012). South Africa has apparently reached a complete standstill in the attempt to decrease neonatal deaths (Velaphi & Rhoda, 2012). Neonatal deaths vary according to the type of hospital. According to SA's sixth perinatal care report between 2006-2007, of early neonatal deaths, 46% occurred in district hospitals and 39% in regional hospitals. LBW infants account for most of these deaths (Velaphi & Rhoda, 2012). Currently, world-wide, breastfeeding (BF) is seen as a primary strategy to improve an infant's nutritional status and to enhance child survival (Siziba et al., 2015). One of the most cost-effective ways to prevent the death of preterm infants is by the introduction of BF and more so exclusive breastfeeding (EBF). Neonatal deaths can be reduced by 41-72% by simply introducing cost-effective and inexpensive interventions for the preterm infant, such as the promotion, protection and support of breastfeeding (Darmstadt et al., 2005).

Unfortunately, despite prevention and treatment programs, HIV remains a problem in SA including amongst pregnant women (Kharsany et al., 2015). Since 2002, the total number of people living with HIV in SA increased from an estimated 4.94 million citizens to 7.06 million by 2017 (Statistics South Africa, 2017). The prevalence of HIV amongst antenatal women was estimated at 30% in 2013 (National Department of Health, 2013). Apart from the risk of HIV exposed infants, HIV infected women, irrespective of antiretroviral therapy ART have a higher risk of poor birth outcomes, including LBW (Xiao et al., 2015).

A national Breastfeeding Consultative Meeting was held in August 2011 in which SA undertook to actively promote, protect and support exclusive breastfeeding as a public health intervention to improve child survival. Due to SA's commitment, a policy was implemented in the country for the protection, promotion and support of appropriate infant and young child feeding in SA. This policy is better known as the Infant and Young Child Feeding (IYCF) policy. This policy is based on the WHO guidelines on HIV and Infant Feeding (WHO, 2016). According to a recent update (WHO, 2016), all mothers are recommended to exclusively breastfeed their infants for the first six months of life, introducing complementary foods after six months, and to continue breastfeeding for 24 months of life or beyond, irrespective of HIV status. Mothers who are living with HIV and who are breastfeeding, should receive fully supported ART, and adherence counselling should be given. Unfortunately, despite these programmes, SA's breastfeeding rates remain shockingly low. According to statistics, exclusive breastfeeding seems to be an uncommon practice in SA (du Plessis et al., 2016). National information regarding our country's breastfeeding practices remain limited, but available data indicates that 88% of mothers can initiate breastfeeding post-delivery, but only 8% of infants are exclusively breast fed from birth to six months of age (du Plessis et al., 2016). Further elaboration regarding breastfeeding in the context of HIV and PMTCT, is done in chapter two of this dissertation.

A mother's own milk is known to almost always be adequate for her infant (Ballard & Morrow, 2012). According to literature, it is possible for the fat content in breast milk and more specifically the alpha-linoleic and decosahexanoic acid, to be altered by the diet (Martin, Ling, & Blackburn, 2016). A lactating mother with a poor nutritional intake, would therefore have less fat in her breast milk than a lactating mother who has an adequate intake of fat. This issue comes into play in developing countries such as SA, where the cost of nutrient dense food is high and therefore dietary intervention would be necessary to supplement inadequate diets (Martin, Ling, & Blackburn, 2016).

Simply by being born too soon, preterm infants are known to have higher energy and protein needs. Adequate nutrition plays a critical role in the preterm infants' growth and development and therefore suboptimal nutrition practices should not occur. Human beings have been created in an astonishingly unique manner in that the milk of the lactating mother of a preterm infant will differ in nutritional composition to that of a mother of a term baby (Ballard & Morrow, 2013). Due to the high risk of necrotising enterocolitis (NEC), studies to date emphasise the importance of providing the preterm infant with breast milk rather than formula milk. It was noted that formula fed infants had a higher risk to develop NEC than those infants receiving expressed breast milk (Ramani & Ambalavanan, 2013). World-wide, current nutritional practices have therefore moved away from feeding preterm infants formula to feeding them with the mothers' own breast milk. The practice of providing breast milk to a preterm infant has increased due to the overwhelming benefits of breast milk (Morlacchi et al., 2016).

1.2 PROBLEM STATEMENT

The Baby Friendly Hospital Initiative is a global programme launched by the WHO and UNICEF. This programme was developed to promote the implementation of the second operational target of the Innocenti Declaration, as well as the "Ten Steps to Successful Breastfeeding". This is also known as the foundation of the WHO/UNICEF Baby Friendly Hospital Initiative" (WHO & UNICEF, 2009). Step 6 of the ten steps to successful breastfeeding, states that new-born infants should receive no food or drink other than breast milk, unless medically indicated. Based on step 6 of the evidence for the ten steps to successful breastfeeding, Blomquist et al. (1994), studied the feeding routines of 521 newborn within maternity units in Sweden and their successive feeding patterns. They concluded that supplementing a new-born due to inadequate milk production, disrupts the mother-child interaction and undermines maternal confidence. The mother is therefore most likely to receive a direct message of “insufficiency” which, in the long run, becomes difficult to overcome (WHO 2006; Blomquist., et al 1994). Practices such as smoking, alcohol abuse and other drug abuse, are prevalent in SA (Pattinson, 2013). Evidence suggests that maternal smoking is negatively correlated with breastfeeding outcomes (Menella, Yourshaw, & Morgan, 2007). Studies also show that women who consume more than two drinks of alcohol per day, were almost twice as likely to discontinue breastfeeding before the infant reaches six months, compared with women who consumed less alcohol (Pattinson, 2013). Sadly, all these aspects impact negatively on breastfeeding outcomes. This means that our preterm infants fall victim to suboptimal nutritional practices and are therefore at a grave deficit in terms of their future growth and development.

Preterm infants do not always catch up to normal rates of growth and it generally takes about 14-17 days for the infant to regain birth weight, especially among extremely low birth weight (ELBW) infants weighing less than 1000g at birth. Very low birth weight (VLBW) infants are known for their rapid deterioration in weight especially within the first few days and weeks of life. This is due to their catabolic nature and poor nutritional intake. Most of these infants are on ventilatory support and this causes systemic inflammatory processes to kick in (Ho & Yen, 2016). Traditionally, preterm neonates with respiratory distress syndrome have delayed initiation of enteral and parenteral nutrition support. This means that enteral feeding is delayed for a few days, thus reaching nutritional and fluid goals becomes harder. This could lead to a plateau phase in the growth velocity of the infant (Ho & Yen, 2016). In 1987, the European Society of Paediatric Gastroenterology and Nutrition (ESPGAN) published recommendations for the feeding management of preterm infants. Recently, an expert group reviewed current evidence and compiled a draft manuscript on recommended intakes of macro and micronutrients for preterm infants. The committee advocates the use of breast milk for preterm infants as standard practice, provided that fortification is added where needed to meet nutritional requirements (Agostoni et al., 2010).

The addition of breast milk fortification was introduced mainly for the benefit of preterm infants. Breast milk fortification is known to increase energy, protein and calcium content of maternal breast milk to, compensate for the preterm infant's higher nutritional needs (Choi et al., 2016). Fortification refers to a powdered substance added to breast milk, and subsequently, the infant by definition, no longer adheres to exclusive breastfeeding. This is currently part of the standard practice in the nutritional management of preterm infants (Choi et al., 2016) It remains questionable whether it is safe for HIV positive mothers to fortify breast milk to their infants, since they, strictly speaking, will not adhere to EBF. Further details regarding fortification can be found in chapter two of this dissertation.

Because optimal nutrition in preterm infants is vital for survival, some hospitals within SA provide human milk fortification to preterm infants as part of their standard nutritional protocol. This is done for the infant to gain weight if breast milk alone failed to produce adequate results. To date, little or no studies support or discourage the use of human milk fortifiers for infants born with LBW, and especially, to HIV positive mothers.

Nelson Mandela Bay (NMB) is known to have the second highest low birth LBWR in the Eastern Cape, as mentioned in the introduction to this chapter. Dora Nginza Hospital (DNH) is situated in Zwide, Port Elizabeth which falls under the NMB. This hospital is known to have a high influx of preterm births because NMB has the second highest rate of babies born with LBW in the Eastern Cape. Considering the poor dietary quality of mothers from underprivileged areas, it is standard practice at DNH to provide lactating mothers with a nutritionally balanced supplement (in the form of an enriched energy drink) to compensate for their lack of adequate nutrition.

Providing lactating mothers with a balanced nutritional supplement has the potential to enrich breast milk without directly supplementing the infant, thus respectfully promoting, supporting and enabling exclusive breastfeeding in LBW preterm infants. However, no data is available to support this practice above the use of human milk fortifier to improve the quality of expressed breastmilk. Additionally, little to no data is available to describe the relationship between growth velocity of the breastfed preterm infant exposed to either maternal supplementation or breast milk fortification.

1.3 RESEARCH QUESTION

The research question was: “Which of the current feeding regimens (maternal supplementation, fortification of BM or the combination of maternal supplementation and breast milk (BM) fortification) support optimal growth velocity in low birth weight hospitalised infants?”

1.4 RESEARCH AIM AND OBJECTIVES

This study aimed to describe the growth velocity in hospitalised low birth weight premature infants receiving breast milk with maternal supplementation, breast milk with human milk fortification, or a combination of the former options, in the NMB Health District. With the proposed study, the researcher aimed to provide recommendations to the Department of Health, EC to strengthen nutrition management of low birth weight infants at hospital level.

The objectives of this study included to:

- Describe maternal socio-demographical, clinical, nutritional status and its relationship with birth outcomes;
- Describe the growth velocity of preterm infants receiving maternal supplementation or breast milk and fortification, or a combination thereof;
- Describe the relationship between infants’ growth velocity with maternal nutritional status, smoking and HIV status; and
- Describe the relationship between growth velocity and the length of hospital stay.

1.5 ROLE OF THE RESEARCHER

Miss R Wicomb (BSc Dietetics) is the principal investigator of the study. The duties of the principal investigator included the development of the research proposal and the submission thereof to the Research Ethics Committee at Nelson Mandela University (NMU). The principal researcher was responsible for the implementation of the pilot study and the summary of its findings. The principal researcher was responsible for calibration of all equipment and for the data collection. The principal researcher was actively and directly involved in the capturing and interpretation of data and preparation of the findings.

1.6 OUTLINE OF DISSERTATION

Chapter 1 of this dissertation introduces the current situation in South Africa regarding preterm infants. Chapter 1 further focuses on the study rationale, problem setting, aims and objectives as well as the layout of the dissertation.

Chapter 2 elaborates on existing literature linking this to the research question. The researcher unfolds the basic and complex physiological processes of prematurity and links this to nutrition and the importance of adequate and appropriate nutrition for these infants. Furthermore, chapter 2 elaborates on the vital importance of breastfeeding for these infants, and the distinct importance it has, not only in terms of nutrition, but HIV/AIDS and poverty as well. The researcher then contextualises the above into a more in-depth understanding of current practices in South Africa, and malnutrition.

Chapter 3 includes the precise details of the methodology used in the implementation of the study. Chapter 3 includes the design, study population and sampling as well as the variables, procedures, validity and reliability of the study. Ethical considerations are an important aspect elaborated on in this chapter.

Chapter 4 includes the results of this study. This chapter describes the demographics, disease, nutritional and social relationship with regard to birth outcomes. Furthermore, this chapter provides the reader with results of the provided interventions and how it affected the growth velocity and the length of hospital stay, in the various test groups.

In chapter 5, the results of the study are discussed in the context of current available literature. The relationships between growth velocity, maternal supplementation and or BM fortification are critically discussed in order to identify whether it had an impact on the growth of the preterm infant. The relationship and trends found are described and contextualised. This chapter provides practical recommendations to ensure adequate growth in preterm infants receiving breast milk in the Eastern Cape. This chapter also covers the limitations of the study.

CHAPTER 2

UNDERSTANDING THE COMPLEX NATURE OF PREMATURITY

2.1 INTRODUCTION

World-wide, a desperate need occured to decrease the child mortality rate by at least two-thirds and subsequently the millennium developmental goals (MDG) were published in September 2000. Initially, the targets of the MDGs were proposed to be reached by the year 2015 (*The Millennium Development Goals Report, 2005)*. MDG number four is the goal intended to decrease the child mortality rate by two-thirds, but this unfortunately has not yet occurred in SA. Globally, 130 million babies are born annually, of which four million will die within the first 28 days of life with the highest risk of death being on the second day of life (Lloyd & de Witt, 2013). Furthermore, an estimated 18 million low birth weight infants are born which accounts for 14% of all births. Of the neonatal deaths, 60-80% are due to prematurity with 19% of these deaths being due to infection (Lloyd & de Witt, 2013).

This chapter focuses on the importance of "being born too soon" to inform the reader of the basic concepts of the underlying motivation towards this study. This chapter covers the basic concepts of prematurity, focusing on the relevant development of the preterm infant and the causes and impacts of being born too soon. The reader is slowly guided into the distinct link between prematurity and nutrition. This chapter emphasises the importance of human milk and the distinct role it plays in the functioning of the preterm infant.

The WHO favours breastfeeding and emphasises in many articles that breast milk is the best nutrition for infants and, more specifically, for the preterm infant. This chapter clarifies the role of breast milk in prematurity, the distinct differences between preterm milk and term milk and the way in which current guidelines are practised.

South Africa is faced with the burden of HIV and AIDS. This chapter focuses on the link between nutrition and the spread of HIV and AIDS in infancy. The prevention of mother to child transmission (PMTCT) has become a common topic and, as research continuously unfolds, so do the guidelines favouring the feeding of breast milk to the infant. It is important to note that the guidelines have always favoured the prevention of the disease and therefore, based on this factor alone, the chapter specifically links prematurity, feeding and PMTCT and the ways in which to manage the current sensitive issue.

Most SA citizens are faced with the reality of poverty. Linked to poverty is the double burden of malnutrition. Malnutrition potentially plays a major role in the nutrition of pregnant and lactating women. More specifically, pregnancy, lactation and inadequate nutritional intake by the mother, go hand in hand. This chapter elaborates on the importance of adequate nutrition during pregnancy and lactation and the effect it has on the foetus and on the infant’s future nutrition.

More specifically, by linking nutrition and poverty, the chapter emphasises the way in which breast milk is affected by poverty by expanding on the specific macro- and micronutrient composition of breast milk. In this chapter, the researcher further tries to emphasise the current situation in SA of inadequate nutritional intake, as well as describe solutions to improve maternal and infant nutrition through breast milk itself.

2.2 THE REALITY OF BEING BORN TOO SOON

Globally, more than one in 10 babies were born prematurely in the year 2010. This contributes to an estimated 15 million preterm births of which more than one million died due to prematurity alone (Blencowe et al., 2013). Of the low birth weight infants born each year, 96.5% are born in developing countries (WHO 2006). The low birth weight rate has been used as a marker for socio-economic and overall status of women and the surrounding community (UNICEF & WHO, 2004). As previously mentioned in chapter one, the low birth weight rate in SA (known as a developing country) is 14.17%. The Eastern Cape Province (EC) has a low birth weight rate of 15.51%. The Nelson Mandela Metropole has a low birth weight rate of 17% and is ranked as the second highest low birth weight rate within the entire Eastern Cape (Pattinson, 2013).

Prematurity is known as the second leading cause of death in children under five years of age (Li Liu et al., 2012). In 2010, an estimated 40% of all deaths in children under five was caused by preterm birth complications, intrapartum related complications and neonatal sepsis or meningitis (Li Liu et al., 2012). When compared with full term infants, premature infants are at a greater disadvantage as they have an increased risk of death and complications (Behrman & Butler, 2007).

Preterm infants are known for their fragile nature; however, this subject area is not very well researched. Preterm birth is known as the most common cause of neonatal mortality (Marchant et al., 2012). Recently, this vulnerable group has been shown more interest from the research world. There is a vast difference in the prevalence of low birth weight across countries and, more specifically, regions and vulnerable populations. Due to the increased rate of child mortality and the number of deaths due to prematurity, global strategies to decrease the child mortality rate demanded urgent attention. However, an astounding 46% of infants are not weighed at birth and therefore this may cause a grave error in the actual prevalence of low birth weight infants (WHO, 2013).

The World Health Association (WHA) Global Nutrition Targets for 2025 are to reduce the number of infants born with low birth weight by 30% in 2025. Low birth weight can be caused by many factors including early induction of labour or caesarean birth, multiple pregnancies, infections and chronic conditions such as Diabetes Mellitus and hypertension (Shaw et al., 2014). The consequences of low birth weight are far more detrimental and can be the cause of neonatal mortality and morbidity, poor cognitive development and an increased risk of chronic diseases later in life (WHO, 2014).

2.3 PRETERM INFANTS DEFINED

A preterm infant, as per the WHO, is defined as infants born alive before 37 weeks of pregnancy have been completed (Quinn et al., 2016). These infants can be categorised according to gestational age and birth weight. When referring to gestational age, refer to extremely preterm (<28 weeks), very preterm (28-32 weeks) and moderate to late preterm (32-<37 weeks) (WHO, 2016). Furthermore, preterm infants classified according to birth weight, are referred to as either low birth weight infants, weighing less than 2.5kg, VLBW infants born less than 1.5kg or extremely low birth weight infants born weighing less than 1.0kg (WHO, 2016). Low birth weight could be due to a shortened period of gestation, prematurity or intrauterine growth restriction, thus, causing the infant to be small for gestational age (Anderson, 2012).

2.4 COMPLICATIONS IN PRETERM INFANTS

The effects being preterm are extensive and include the effect on the individual, the family, community and the economy. The complications of being preterm stem from organ immaturity, i.e. the infant's organs are not fully capable of surviving life outside the extra-uterine environment (Miller, 2017). The degree of overall organ immaturity is depicted when correlating the risk of acute neonatal illness with gestational age. The risk of acute neonatal illness decreases with gestational age and thus it can be generally concluded that the more immature preterm infants require more critical life support (Behrman & Butler, 2007).

Because preterm infants have an immature gastrointestinal tract and immune system, it predisposes them to infectious morbidity (Juvé-Udina et al., 2015). During the period of organ immaturity, nutrition plays a vital role towards immunological and metabolic development and microbiological programming. Breast milk is known as the best way in which to protect the gut barrier and increase the maturation of the gut-related immune response. This means that environmental exposures such as nutrition can cause permanent changes in the physiological processes. Environmental exposures are known to be an important aspect of developmental maturation of many organ systems and optimal physiological functions (Collado et al., 2015).

Due to the complex nature of prematurity, most infants face a lifetime of prolonged unfavourable health outcomes (WHO, 2016) such as retinopathy of prematurity, bronchopulmonary dysplasia, or periventricular leukomalacia (Collado et al., 2015). Preterm infants are also known to have an increased risk of neurodevelopmental deficits such as an increased risk of developing cerebral palsy (Miller, 2017). These unfavourable health outcomes result in tremendous physical, psychological and economic costs (WHO, 2016).

2.5 CAUSES OF PRETERM DELIVERIES

The causes of preterm birth are complex and the pathophysiology that triggers preterm birth is unfortunately unknown (Quinn et al., 2016). Preterm birth is a phenomenon that could be caused by many factors such as individual-level behavioural and psychosocial factors, medical conditions, biological factors, genetics and environmental factors (Behrman & Butler, 2007). For this study, and since the population studied are socio-economically disadvantaged, the focus below will be on health and behavioural influences on preterm birth. Key risk factors associated with preterm birth include hypertension, smoking, excessive alcohol intake and recreational drug use during pregnancy (Smith et al., 2015).

2.5.1 Tobacco use

Tobacco use is known to be the most prevalent, preventable cause of unfavourable pregnancy outcomes. There is a strong correlation between smoking and placental abruption, reduced birth weight and infant mortality (Behrman & Butler, 2007). There is a moderate and inconsistent correlation between tobacco use and preterm birth. There has been no increased risk found reported for former smokers who quit prior to the onset of pregnancy or early in pregnancy (Behrman & Stith Butler, 2007) Evidence exists to show that there is an increased risk in preterm birth even in the lowest dose range of tobacco use (0-10 cigarettes per day) (Savitz & Murnane, 2010). In a population-based case-cohort study done by Smith et al. in 2015, women who smoked during pregnancy had a 38% higher risk of late to moderate preterm birth compared with those mothers who had never smoked regularly. Interestingly enough, there was no evidence to support an increased risk of late to moderate preterm birth for women who stopped smoking before or during early pregnancy (Smith et al., 2015).

2.5.2 Alcohol and drug use

The use of alcohol and drugs has been associated with age, poverty, unemployment, interpersonal conflict, mental and psychological disorders and suicidality among pregnant women. Low income pregnant women are known to have an increased susceptibility to the use of alcohol and drugs in both developing and developed worlds (Onah et al., 2016). It is known that high levels of alcohol usage during pregnancy are linked with unfavourable outcomes for the development of the foetus (Behrman & Butler, 2007). Alcohol use during pregnancy has been proved as one of the main avertable causes of birth defects and developmental impairment in children (Onah et al., 2016). Frequent alcohol and drug use has been associated with poor weight gain during pregnancy, decreased foetal growth and preterm deliveries (Onah et al., 2016). Savitz and Pastore (2010) concluded that there is in fact an association between moderate alcohol use and preterm birth. This, however, could be a result of a higher prevalence of low alcohol usage amongst socio-economically advantaged women (Behrman & Butler, 2007). The relationship between preterm birth and maternal alcohol use however, remains unresolved. (Behrman & Butler, 2007).

Most research available has focused on the potential effect that marijuana and cocaine have on preterm birth. There is insufficient evidence proving that marijuana use influences preterm birth (Behrman & Butler, 2007).

Although not seen as a behavioural factor, pre-pregnancy weight is associated with diet and nutrition. Low pre-pregnancy BMI is associated with an increased rate of preterm birth (Savitz et al., 2012).

Interestingly enough, a cohort study done with 1 599 551 deliveries, found that the risk of extremely, very and moderately preterm deliveries increased as maternal BMI increased (Cnattingius, 2014).

2.5.3 Pre-pregnancy weight gain

In the South African Demographic and Health Survey (2016), BMI was calculated on 82% of women older than 15 years in SA. Based on BMI score, two thirds (68%) of women were overweight or obese. Furtheremore, this survey states that one in five women suffer from severe obesity (BMI>35kg/m^2) and that 40% of women in EC suffer from obesity. Obesity in the EC is therefore a serious health issue. Current research states that pre-pregnancy overweight or obesity is the leading avoidable risk factor for the development of hypertensive disorders in pregnancy (Adane, Mishra & Tooth, 2017). Therefore, as maternal BMI increases during pregnancy, so does the risk of preterm delivery and other maternal complications. The obesity-prematurity relationship is compounded, with hypertensive disorders of pregnancy playing a critical role (Madan et al., 2009).

2.5.4 Gestational hypertension and preeclampsia

Gestational hypertension can be defined as hypertension that develops for the first time after 20 weeks gestation (Magee, Pels, Helewa, Rey & von Dadelszen, 2014). Gestational hypertension is known as the most common medical complication that can occur during pregnancy (Adane, Mishra & Tooth, 2017). Gestational hypertension is known to influence mortality, with lower odds of mortality prevalent in infants born to mothers with hypertension (McBride, Bernstein, Badger & Soll, 2015). A link exists between preterm birth and hypertension and is independent of birth weight. This link has been clearly proven in various epidemiological studies (Sutherland et al., 2014).

Foetal growth is a good indicator of the well-being of a foetus. Intra-uterine growth restriction (IUGR) is a pathological process whereby the foetal growth is known to be inadequate and therefore increases the risk for perinatal mortality (Backes et al., 2011). Pre-eclampsia is a known risk factor for, and, also known as the most common cause of IUGR and is known to increase the risk of mortality (Backes et al., 2011).

Pre-eclampsia is an event that only occurs during pregnancy and can be diagnosed as mild, moderate or severe. This can be defined based on different criteria and is usually diagnosed after 20 weeks of gestation (Wagner, 2004). Severe pre-eclampsia can be defined as blood pressure of more than 160mm Hg(systolic) or 110mm Hg (diastolic), proteinuria of more than or equal to 5g per day and or thrombocytopenia, pulmonary oedema or oliguria. Mild pre-eclampsia can be defined as a blood pressure of less than 160mm Hg (systolic) or 120 mm Hg (diastolic) with the presence of proteinuria higher than 300mg but less than 5g per day (Backes et al., 2011).

Pre-eclampsia is linked to both preterm and small for gestational age (SGA) births. This can be attributed to a decreased placental function leading to inadequate transfer of nutrients to the foetus. The mother's nutritional status influences her risk of having pre-eclampsia. Pre-eclampsia is known to contribute to preterm delivery (Davies, Bell & Bhattacharya, 2016). A large trial conducted by the WHO, confirm that an effective nutritional intervention to decrease the incidence of pre-eclampsia (and simultaneously prematurity) is providing calcium supplementation during pregnancy to those women who have a low calcium intake (WHO, 2014).

2.6 DEVELOPMENT OF THE PREMATURE INFANT

The neonatal period is defined as the period from birth (perinatal period) to the 28th day of life. This is a critical period of vast transitioning from the infant's uterine environment to the external world (WHO, 2016). Extra-uterine growth restriction is a huge clinical issue, especially in very low birth weight infants. Growth failure in these infants are due to many factors including morbidities affecting nutrient requirements, endocrine abnormalities, insufficient suck and swallow coordination, central nervous system damage and administration of medication that affect nutrient metabolism (Su, 2014). Preterm infants are subsequently a vulnerable population. The specific terminology pertaining to prematurity requires clarification to understand the holistic managent of preterm infants (Sharma, Shastri & Sharma, 2016).

The full-term infant is born between the 37th and 42nd weeks of gestation. The preterm infant is born before 37 weeks of gestation, whilst a post-term infant is born after 42 weeks gestation. Postnatally, gestational age is estimated upon clinical assessment, i.e. examination of neurological signs and any external characteristics seen as physical maturity in the infant. An accurate gestational age is vital in order to determine nutritional goals for the individual infant and in order to distinguish between the preterm infant and the SGA infant (Anderson, 2012).

A SGA infant is an infant whose birth weight plots lower than the 10th percentile of the standard weight for the proposed gestational age. The SGA preterm infants are more likely to develop postnatal growth restriction in the early neonatal period. Infants who are appropriate for gestational age (AGA) plot with birth weights between the 10th and 90th percentiles on the intrauterine growth chart (Blake et al., 2016). The AGA preterm infants, along with SGA infants, portray postnatal growth restriction at hospital discharge. This is because they have minimal protein and energy storage space (Roggero et al., 2011). The terms SGA and intrauterine growth restriction (IUGR) should not be used interchangeably, as the definitions differ. Intrauterine growth restriction can be defined as inadequate growth in utero against the expected foetal growth potential. Intrauterine growth restriction results from an innate reduced growth potential and presents with clinical features of malnutrition and in utero growth restriction, and does not discriminate against birth weight (Sharma, Shastri & Sharma, 2016). The incidence of IUGR is six-fold greater in developing versus developed countries. Asymmetric intrauterine growth restriction can be defined as an infant who has inadequate intra-uterine weight gain but whose linear and head growth plot between the 10th and 90th percentiles on the intrauterine growth grid. Symmetric IUGR is a reflection of early and long-standing intrauterine deficit and is much more detrimental to later growth and development. Future growth and development of infants who have IUGR vary and depend on the cause and treatment (Anderson, 2012). Adolescent and pre-pregnancy nutrition, pre-pregnancy weight and poverty are the most important determinants of foetal growth in developing worlds (Sharma, Shastri & Sharma, 2016).

When referring to the literature above, nutrition plays not only a vital role in the preterm infant, but a vital role in the foetus as well. Pre-pregnancy weight and the implications that poverty has on the mother and infant, are both linked to birth outcomes. The importance of maternal nutrition during pregnancy shapes the growth and development of a mother's unborn child. With poor maternal nutrition and social practices during pregnancy, implications such as SGA, IUGR and impaired growth and development await the unborn infant.

2.6.1 Development of the upper gastro-intestinal tract

The upper gastro-intestinal tract consists of the oesophagus, stomach and duodenum (Waldum, Kleveland & Fossmark, 2015) and is one of the first structures to be identified within the embryo. The intestinal tract grows the most in length during the final trimester of pregnancy and continues at a slower pace up to 3-4 years of age (Uesaka et al., 2016).

Swallowing occurs at 11-16 weeks and sucking develops at 18-24 weeks. The gag reflex is present at 25-27 weeks, even though organized oesophageal activity only presents itself by roughly 32 weeks gestational age and does not work in harmony with swallowing until 33-34 weeks gestational age. Between 33-34 weeks of gestational age, the preterm infant can perform a swallow and breathe pattern (WHO, 2018). Once reaching 32-34 weeks the preterm infant can attach and suck in such a manner that the infant is able to perform breastfeeding. Swallowing occurs after 16 weeks gestation. The amount swallowed by the infant increases and causes a variation within gastric volume. The suck-swallowing reflex and breathing is enhanced after 32-34 weeks of gestation (Martinez, 2001).

The lower oesophageal sphincter is not well formed in the preterm infant and is therefore a poor anti-reflux barrier. At 27-28 weeks gestation, this sphincter generally resists a 4 mmHg pressure, whilst in full term infants, it resists 18 mmHg. The pressure is decreased via the orogastric tube and decreased even more by administering caffeine to the infant. The immaturity of the lower oesophageal sphincter therefore is a cause of gastro-oesophageal reflux which usually presents with vomiting, oesophagitis, recurrent apnoea, pulmonary aspiration, deterioration of pulmonary dysplasia and growth difficulties (Martinez, 2001).

Gastric emptying is generally slow in premature infants and therefore affects their tolerance to feeds. Gastric emptying is faster and therefore intra-gastric pressure is known to be elevated with an increase in gestational age. Gastric emptying is slower with formula milk than with breast milk (Martinez, 2001). The whey fraction found in BM is highly soluble in gastric juices compared to casein found in some formula milk (Gridneva et al., 2016).

Mature motility of the small intestine is found after 32-34 weeks gestation. The maturing of motility and feeding tolerance are improved with early introduction to enteral feeding. Trophic feeding can be defined as minimal volumes of milk usually between 10-15 ml/kg/day (Dutta et al., 2015). In practice, trophic feedingis known to enhance and stimulate the maturation of the intestine (Martinez, 2001).

Delayed growth and development of the upper gastro-intestinal tract negatively affects the nutritional management of these infants increase length of hospital stay. A simple delay in the suck swallow reflex can increase the risk for gastro-oesophageal reflux, aspiration and delay oral nutrition through breastfeeding. A delay in breastfeeding means that the mother would need to express her breast milk for a prolonged period. This is a tedious and stressful period for the mother. All the above factors can alter the nutritional management and progression of preterm infants and add to the cost of hospitalisation.

2.6.2 Brain development

The human brain is a dynamic organ as it continues to develop and change throughout the cycle of life. The most crucial period of brain growth is during the final trimester of pregnancy and the first two years of life. At five months post-conception, the human brain is a smooth, bi-lobed structure (Cusick, 2016). During the final few weeks, within the third trimester of pregnancy, as many as 40,000 new synapses are formed every second. By nine months or full-term birth, the human brain has already developed gyri and sulci and resembles the walnut-like adult brain. During the first postnatal year of life, the language processing areas and early development of the prefrontal cortex develops (Cusick, 2016). The first 1000 days contain periods of neuronal proliferation, growth and differentiation, myelination and synaptogenesis and therefore provides the best window of opportunity for ensuring normal development in terms of brain functioning and optimal nutrition (Cusick, 2016).

Optimum development of the brain relies on adequate nutrition during certain periods of sensitivity within the first 1000 days of life. The brain consists of various separate areas and each area's growth differs and subsequently interconnects to produce a complex organ that ultimately directs human behaviour. The different regions of the brain expand and reach periods of exponential growth at various times, with each point needing specific nutritional requirements (Cusick, 2016). Low birth weight infants and prematurity usually go hand in hand. In utero factors cause term infants to develop low birth weights. Prematurity also results in the interruption of crucial processes involving early brain development as mentioned above. This means that preterm and LBW infants are at an increased risk for numerous developmental issues relating to health, psychological adjustment and intellectual functioning (WHO, 2011).

2.6.3 The nutritional consequences of prematurity

The first three years of a child's life play a crucial role in brain development. Any experience during this period may have lifelong effects on intellectual, emotional and social functioning (WHO,2011). The period from conception until two years of age, is the most important of all and is known as the first 1000 days of life. This poses a window of opportunity is to lay a firm lifetime foundation in terms of the development of optimum health, growth and neurodevelopment outcome (Cusick, 2016).

With reference to the definition of prematurity, preterm infants do not have the chance to reach its full developmental potential in utero and differs physiologically to a term infant. Low birth weight infants therefore present with various clinical problems during the early neonatal period and the extent of the problems also depends on their intrauterine environment, degree of prematurity, birth related trauma and the function of immature or stressed organ systems (Anderson, 2012).

Premature infants are at a higher risk for suboptimal nutritional status. This is due to the poor availability of nutrient stores, physiologic immaturity and illness. With reference to the development of nutrient stores in-utero, most stores are deposited within the last three months of gestation and thus the premature infant begins life in a compromised state (Belfort et al., 2016). As previously mentioned, because premature infants have poor nutrient stores, it is vital to start parenteral or enteral nutrition immediately. Nutrient stores are depleted at a faster pace in infants who have IUGR due to their increased metabolic needs (Anderson, 2012).

In practice, it becomes difficult to provide adequate nutrition during the first few days of life. Since the organ systems are immature and complicated medical problems occur, the infant is required to be fluid restricted. When inadequate nutritional intake occurs in premature infants, the fat and glycogen stores are depleted, and the infant begins to catabolise essential body protein tissue for energy. This simultaneously decreases the chances of survival of the preterm infant (Anderson, 2012).

When referring to nutrition and considering the practical aspects mentioned above, in practice, fluid restriction delays progression to full feeds and, at the same time, delays the achievement of sufficient weight gain for the infant, once again affecting its nutritional management.

2.7 NUTRITION MANAGEMENT OF PRETERM INFANTS

2.7.1 Fluid

Fluid requirements in the preterm infant vary greatly between 135 and 200 ml/kg/day. These parameters need to be considered according to tolerance and are known as the lower and upper limits. Postnatal intakes given at the lower range is highly likely to decrease the risk of long term morbidity (bronchopulmonary dysplasia and patent ductus arteriosus). The fluid management for these infants are based on the volumes required for enteral nutrition and are influenced by osmolarity and renal solute load. It is therefore important to note that these are not identical to actual water needs (Agostoni et al., 2010).

For feeding purposes, 150-180ml/kg/day as a volume derived from standard formula or breast milk, is aims to achieve the nutrient requirements (Agostoni et al., 2010).

2.7.2 Energy, protein, fat and carbohydrates

Due to the intricate nature of prematurity and since preterm infants should mimic the growth of an infant in-utero, preterm infants have a higher need for energy compared to term infants. More specifically, these infants have a higher need for production and synthesis of new tissue. Due to their delicate skin, premature infants have increased losses in heat and water through evaporation (Martinez, 2001).

Administration of medication such as caffeine and antibiotics to the infant cause an increase in their energy expenditure. A major factor to consider is that these infants do not have fully developed lungs and therefore suffer from respiratory difficulty and become septic at a faster rate than a normal infant, which increases their energy expenditure (Shane & Stoll, 2014). Rapid weight gain in preterm infants is ideal to improve neuro-developmental outcomes (Belfort, Gillman, Buka, Casey & McCormick, 2013); however, it is important to monitor growth velocity as rapid weight gain is associated with cardiovascular risks. Therefore, optimal growth velocities need to be practised as part of nutritional support (Kumar et al., 2017). In a cohort of preterm LBW infants born in the 1980's reviewed by Belfort et al (2013), earlier linear growth after term was associated with an improved congnitive outcome, but also associated with later overweight or obesity later in life. Belfort et al (2013) further explains that excessive weight gain outside the linear growth pattern from term to 18 months of age was associated with overweight and obesity (Belfort, Gillman, Buka, Casey & McCormick, 2013) .

Energy needs for healthy preterm infants vary according to the post-conception age, nutrient deficits (pre and postnatal growth restriction), changes in body composition and the difference in resting energy expenditure (Agostoni et al., 2010).

Infants categorised as small for gestational age could possibly require a higher energy intake than do infants classified as being of appropriate weight for gestational age. It should be noted that directing the focus on achieving an ideal lean mass accretion instead of fat mass accretion would be more desirable. Higher intakes of 140-150kcal/kg/day are known to be safe as short-term management; however, there is little evidence to prove that there is a greater linear growth, while fat mass deposition appears excessive (Agostoni et al., 2010).

In summary, the recommendation of energy intake to achieve sufficient growth in preterm infants with an adequate protein intake, is 110-135 kcal/kg/day. It should be noted that increasing the amount of energy intake alone is unable to influence sufficient growth for the infant. When considering the nutritional requirements of preterm infants, the emphasis should be on both energy and protein as a unit (Agostoni et al., 2010).

Proteins are compounds composed of carbon, hydrogen, nitrogen and oxygen. These are patterned in strands of amino acids. Proteins are known to play a vital role in the cellular maintenance, growth and functioning of the body (Dib & Carbone, 2012).

Insufficient intake of protein is may lead to lower cognitive achievements. Protein needs are higher in the more immature preterm infant depending on the feeding policy, tolerance and illness. The quality of protein can be defined as characteristics of a protein in relation to its ability to achieve defined metabolic actions (Millward, Layman, Tomé & Schaafsma, 2008). Protein quality is very important as preterm infants require protein in the form of amino acids. Based on the protein needs and nitrogen management of the body, the protein intake should be a minimum of 3 g/kg/day. By using growth velocity as a guide, a maximum protein intake of up to 4.5 g/kg/day is acceptable; ESPHAGEN recommends a protein intake of 3.56-4.5 g/kg/day (Agostoni et al., 2010).

Lipids are a group of compounds which consist of elements such as carbon, oxygen and hydrogen. Lipids are found mainly in plants and animal sources such as fish and meats. Lipids are from a major part of cell membranes in the body and aid with the absorption of vitamins A, D, E and K. Lipids are stored as fat (adipose tissue) add insulation and therefore play a role in thermo-regulation of the human body and simultaneously provide the body with energy (Martin, 2015).

Dietary lipids play an essential role in preterm infants as they receive most of their energy in the form of fats. Lipids therefore provide most of their energy needs in the form of essential polyunsaturated fatty acids and fat soluble vitamins. The amount and composition of dietary lipids affect the growth pattern and body composition of the infant (Martin, 2015). Long chain polyunsaturated fatty acids (LCPUFA) are derived from two main polyunsaturated fatty acids; α- linolenic acid (ALA) a linoleic acid. ALA, is found in plant-based foods (examples are walnut and flaxseed oils), and the body is unable to synthesise it. This makes ALA essential fatty acid as it is needed to be obtained from dietary sources (Abedi & Sahari, 2014). Brain grey matter and the retina of the eye consist of high values of long chain polyunsaturated fatty acids and complex neural functions are linked to energy supply and the consistency of dietary fatty acids (Agostoni et al., 2010).

ESPHAGEN recommends a fat intake range of 5.7-6 g/100kcal (Agostoni et al., 2010). These parameters are generally like the upper range of human milk samples.

Carbohydrate can be defined as compounds that consist of carbon, oxygen and hydrogen, arranged as monosaccharides or multiples of monosaccharides. Most, but not all carbohydrates, have a ratio of one carbon molecule to one water molecule" (Agostoni et al., 2010). Carbohydrates are the main source of energy. Glucose is a vital source of energy for the human brain. The lower limit for carbohydrate intake is calculated using the energy requirements of the brain and other glucose dependent organs, thus, aiming to decrease the irreversible loss of protein and nitrogen by avoiding gluconeogenesis and thus avoiding ketosis. A minimum of 10.5g carbohydrates per 100kcal is recommended for preterm infants (Agostoni et al., 2010).

2.8 EXPECTED WEIGHT GAIN IN PRETERM INFANTS

Growth in preterm infants is a complex process. Due to its physiology and being born too soon, it is recommended that a preterm infant grows according to the same rate as the healthy unborn foetus, using the Fenton growth chart for preterm infants, until the preterm becomes a term infant (Euser et al., 2008). Weight gain in preterm infants varies greatly depending on birth weight and gestational age (Kent et al., 2006). Birth weight and gestational age are very good factors to help determine the quality of life of a new-born infant (Vieira & Linhares, 2016).

It is expected that a preterm infant's growth increases and accelerates between 36 and 40 weeks gestational age. This is when most preterm infants will undergo catch up growth. Catch up growth can also be defined as a period of growth recovery during which growth is faster than calculated or expected. Catch up growth can be calculated using growth velocity (Raaijmakers & Akkegaert, 2016). More specifically, a preterm infant whose head circumference, length and weight plots below the lowest percentile or z-score on the postnatal growth curve is expected to catch up to the normal growth of a healthy full-term infant within the first 12 months of the infant's life (de Wit et al., 2013).

A few factors should be considered in the growth of a preterm infant.

2.8.1 Assessment of growth

Growth is measured by observing changes in anthropometric measurements i.e. weight, length, head circumference and mid-upper arm circumference. It is important that growth is assessed on a continuous basis and not just as a once-off measurement, thus, monitoring a trend in weight fluctuations. It is vital that weight be measured over the infant's first few years of life as the preterm infant undergoes catch up growth earlier than full term infants. Corrected age is also better known as adjusted age. This is a simple formula in which the infants age is based on its due date (Engle, 2006). Catch up growth generally occurs for these infants by 12 months of corrected age (de Wit et al., 2013).

The decision on how to decrease the prevalence of failure to thrive is generally an individualised approach as this varies greatly depending on gestational age, physiological development, clinical progress and specific nutritional intervention (Jaffe, 2011). The most critical aspect when managing preterm infants, is to ensure that growth rates are always available on record (Anchieta, Xavier & Colosimo, 2004). Another important factor to consider is the precise and consistent attention to weight gain. When assessing or measuring growth velocity, it is important to pay careful attention to the method of growth monitoring and the way in which weight gain is calculated. Using absolute growth rates, presented as grams per day (g/day), is not suitable as absolute growth provides an incorrect impression of weight gain. Relative rates measured in gram per kilogram per day (g/kg/day) provides a better indication of adequate growth rates (Klein, 2002).

Because nutrition plays such a vital role in the preterm infant's future growth and development, precise growth monitoring protocols are needed to put in place. If an infant does not reach catch up growth, failure to thrive occurs, affecting development. By monitoring growth velocity, health professionals can determine the progression of growth in the infant. The recommended growth velocities in preterm infants remain controversial although some literature encourages the use of 10-15g/kg/day (Moltu et al., 2014; Martin et al., 2009).

2.9 MATERNAL NUTRITION: NUTRITIONAL STATUS AND WEIGHT GAIN

South Africa is a developing country associated with poverty. Trends in food security status in SA indicate that those experiencing hunger and those at risk of hunger have increased in number. From 2010-2014, SA experienced a rise in the percentage of citizens experiencing hunger within households from 13.5% to 16.2%. The reason for the rise in hunger was mostly notable in the Northern Cape (19.4-29%) and Eastern Cape (18.6-24.5%) (Statistics South Africa, 2016).

South Africa is experiencing a nutrition transition. A nutrition transition typically occurs in low and middle-income countries (Kimani-Murage, 2013). The nutrition transition can be defined as a shift in dietary intake (usually at the community or population level) and energy expenditure linked with economic, demographic and epidemiologic changes (Steyn & Mchiza, 2014). The changes in dietary patterns are from less unrefined foods and carbohydrates to an increase in animal protein, saturated fatty acids (SFA) and sugar (Steyn & Mchiza, 2014). This transition is associated with a shift from periods of famine, to receding famine, to nutrition related chronic diseases of lifestyle (Steyn & Mchiza, 2014).

South Africa, experienced an increase in levels of HIV/AIDS coupled with the exponential increase in economic and social transition and urbanisation and has undergone a complex health transition. South Africa’s nutritional transition is better described as high levels of persistent under-nutrition amongst the Black population. This can be due to an increase in food insecurity at the household level (Kimani-Murage, 2013).

A woman’s pre-pregnancy BMI determines the total amount of desirable weight gain and rate of weight gain during pregnancy. The Institute Of Medicine, 2009, guidelines recommend that women conceive at a normal weight in order to reach ideal maternal and neonatal outcomes (Kominiarek & Rajan, 2016).

Pregnancy is a period of rapid weight gain to support foetal growth. The double burden of malnutrition is defined as under and over nutrition along with overweight and obesity, or diet related non-communicable diseases, within individuals, households and populations, and across the lifecourse (“Double burden of malnutrition”, 2018). The link of the double burden of malnutrition coupled with the nutritional transition facing SA from a nutritional perspective, it is obvious that mothers who live in poverty tend to struggle with a lack in dietary diversity during pregnancy. Weight gain during pregnancy is BMI specific and if a mother does not gain the necessary weight needed during pregnancy it is possible for her to give birth to a LBW infant with poor perinatal and neonatal outcomes (Kominiarek & Rajan, 2016). Adequate nutrition and weight gain for pregnant mothers is therefore of critically importance to birthing, growth and development outcomes of their infants.

Lactating and pregnant mothers in SA are at a nutritional deficit due to the rise in household food insecurity and the double burden of malnutrition. This is because pregnant and lactating mothers have higher nutritional requirements to compensate for the nutrient requirement of their infant (Marangoni et al., 2016).

2.9.1 Nutritional needs during pregnancy

Physiological changes that occur during pregnancy, include hormonal, blood volume and composition, and weight gain. Nutritional needs during pregnancy are thus increased and the accurate determination of the nutrient needs are often complex (Marangoni et al., 2016).

2.9.1 a) Energy and protein

Energy intake is estimated to increase by 300 kcal per day during pregnancy. An estimated 80 000 kcal are needed to support a full-term pregnancy. Energy needs during pregnancy differ slightly according to trimester (Kominiarek & Rajan, 2016). During the first trimester, energy requirements remain the same as for the non-pregnant woman. During the second trimester, energy requirements increase with 340 kcal per day and in the third trimester energy requirements increase with 452 kcal. Energy requirements differ according to maternal age, BMI and activity level. It is recommended to incorporate an individualised approach according to these factors (Kominiarek & Rajan, 2016).

Generally, non-pregnant women have a recommended protein intake of 0.8 g/kg/day. Protein is known to be estimated at an extra 1 g/day in the first trimester, 8 g/day in the second trimester and 26 g/day in the third trimester of pregnancy (Marangoni et al., 2016). An excessively low protein intake during pregnancy is associated with negative effects in terms of weight and length of the infant at birth (Marangoni et al., 2016).

2.9.2 Maternal nutritional needs during lactation

Breast milk is the ideal source of nutrition for an infant (Rollins et al., 2016). Suboptimal BF practices cause extensive health costs that reach far beyond infant.

Poor nutritional status of the mother can affect the nutrition of her infant. This concept is linked to the first 1000 days of life which emphasises the importance of adequate nutrition for women and children in order to prevent malnutrition in early infancy (Cusick & Georgieff, 2016). Because preterm infants are wholly dependent upon their mothers as the sole source of nutrition, in order to prevent malnutrition in preterm infants, optimum maternal nutrition during lactation has the power to improve nutrition for the infant (Kominiarek & Rajan, 2016).

2.9.2 a) Energy and protein

Breastfeeding women need an estimated extra 500 kcal per day in their diet compared with non-pregnant women. This energy estimation is based on the average volume of breast milk produced by mother per day and the energy content of the breast milk. During pregnancy, most mothers store an additional 2-5 kg in tissue, mainly as fat, in physiologic preparation for lactation. Women who are unable to consume the recommended extra 500 kcal will use their body stores to maintain lactation (Kominiarek & Rajan, 2016). The recommendation for energy intake during the first six months of lactation is to include an additional 500 kcal into the maternal dietary intake (Picciano, 2003). Table 2.1 depicts the average recommended dietary allowances for non-pregnant, pregnant and lactating women (Eggert & Rayburn, 2009).

Table 2. 1: The difference in selected nutrient needs between pregnant, non-pregnant and lactating women (Eggert & Rayburn, 2009)

Nutrients	**Non-pregnant women**	**Pregnant women**	**Lactating women**
Carbohydrate (g/kg/day)	100	135	160
Protein (g/kg/day)	0.66	0.88	1.05
Fat-soluble vitamins			
Vitamin A (μg retinal equivalents)	700 (5000 IU)	750 (5360 IU)	1200 (8571 IU)
Vitamin D (μg)	15 (400 IU)	15 (400 IU)	15 (400 IU)
Vitamin E (α-tocopherol equivalents)	15 (30 IU)	15 (30 IU)	19 (38 IU)
Water-soluble vitamins			
Vitamin C (mg)	75	85	120
Vitamin B1 (mg)	1.1	1.4	1.4
Vitamin B2 (mg)	1.1	1.4	1.6
Niacin (mg)	14	18	17
Folic acid (μg)	400	600	500

Table 2.1 (continued)

Nutrients	**Non-pregnant women**	**Pregnant women**	**Lactating women**
B6 (mg)	1.3	1.9	2.0
B12 (μg)	2	2.2	2.4
Minerals			
Calcium (mg)	1000	1000	1000
Magnesium (mg)	320	350–400	310–320
Iron (mg)	18	27	10
Zinc (mg)	8	11	12

Generally, lactating mothers' protein requirements increase by 25 g/day (Kominiarek & Rajan, 2016). There is a difference between the average recommended protein intake of a healthy mother and that of a malnourished mother. Healthy mothers produce breast milk with an average of 1.09 g/dl protein versus chronically malnourished mothers who produce 0.93 g/dl of protein. Those mothers who are chronically 'moderately' malnourished are usually found in developing countries such as SA. These mothers are known to weigh less than 90% of the standard weight for height and generally consume less than 50 g of protein per day (Eggert & Rayburn, 2009). In some studies, done in developing countries, supplementing with protein alone caused an elevation in the protein content of breast milk and increase the daily weight gain in infants. Therefore, a healthy lactating mother with a protein intake of 1.05 g/kg/day needs no additional supplementation (Eggert & Rayburn, 2009).

2.9.2.b) Fat

Fat is an important macronutrient found in breast milk as it is the main source of calories in breast milk. Fat aids in the optimum development of an infant (Kelishadi, et al., 2012). Breast milk generally contains 52% of its calories as fat. Breast milk and standard infant formula contain roughly 3.6 g of fat per 100 ml (Kelishadi et al., 2012).

Polyunsaturated fatty acids (PUFAs) are precursors of LCPUFA. An example of a PUFA as mentioned in chapter one of this study, is linolenic acid (LA) and ALA. Examples of LCPUFA are arachidonic acid and decosahexanoic acid (DHA). These important fats are vital to sustain brain and retinal development during the perinatal development (Kelishadi et al., 2012). The body receives all the essential fatty acids (EFA) from the diet and therefore the amounts of LA found in linseed and other oils, and DHA, present in fish and marine animal oils, in different blood lipid pools and tissues have been proven to impact on dietary intake (Lauritzen & Carlson, 2011). Long chain polyunsaturated fatty acids are present in the membranes of the foetus and infant. Martinez (1992) states that as the amount of membrane fatty acids (as DHA) increases in quantity as the brain grows. This process continues for the second year of life despite the plateau in brain growth (Martinez, 1992).

The benefits of DHA for the growing foetus and infant is supported by literature that confirms the importance of appropriate omega 3 intake for maternal health, the composition of breast milk and for overall infant health (Lauritzen & Carlson, 2011; Sallis et al., 2014; Mennitti et al., 2015). Special population groups such as mothers who smoke during pregnancy and lactation, might need more DHA. Infants who are born to mothers who smoke are often small for gestational age and have been linked with a low provision of DHA with breast milk to the new-born infant (Marangoni et al., 2016).

The fatty acid composition of breast milk correlates with the fatty acid composition in maternal plasma lipids (Lauritzen & Carlson, 2011). The ratio of ALA to LA within breast milk, however, has been proved to be more elevated compared to plasma level. These observations therefore conclude that omega 3 fatty acids are specifically found within breast milk. The ratio of LCPUFA to EFA has been proved to be less in breast milk versus plasma. Lauritzen & Carlson (2011) describe the specific dietary issues in low income countries and correlate the maternal dietary intake with the amounts of DHA found within breast milk. This review article concluded that the supply of LCPUFA from the mother to infant and the status of the mother and infant, are dependent upon the mother's dietary intake of LCPUFA. The study further concludes that the omega 3 LCPUFA supplementation is much more effective than ALA supplementation, whilst bearing in mind that the ALA supplementation, could be vital for those mothers with a low total fat intake (Lauritzen & Carlson, 2011).

Within poor economic environments, it is costly to consume a diet rich in "good fats", better known as essential fatty acids. Naturally, women living in poor economic circumstances have a lack of dietary diversity and these women are most likely be deficient in MUFAs and PUFAs. Pregnant and lactating women living in poor economic circumstances and lacking dietary diversity, are possibly at an even greater nutritional disadvantage. The reason for this is that the infant's nutritional needs take priority over that of the mother's. This means that whichever macro and micro-nutrients are needed by the infant, are removed from the mother's nutritional stores first before her body utilises it for its own normal functioning (Marangoni et al., 2016). If pregnant and lactating mothers suffer from nutrient deficits, the nutritional composition of their breast milk becomes questionable. In order to correct the deficit of costly fats, such as MUFAs and PUFAs, and possibly improving on their dietary diversity, supplementation becomes necessary. It would thus be logical to incorporate a balanced nutritional supplement including PUFAs and MUFAs for those lactating mothers to improve breast milk quality (Segura, 2016).

2.10 THE ROLE OF BREAST MILK IN THE PRETERM INFANT

According to WHO, "breastfeeding is an unequalled way of providing ideal food for the healthy growth and development of infants" (WHO, 2013). Breastfeeding is the ideal source of nutrition for an infant from 0-6 months of age. Infants should be exclusively breastfed for the first 6 months of life to achieve optimum health, growth and development. As per WHO definition, exclusive breastfeeding means giving a baby only breast milk, and no other liquids or solids, not even water although drops or syrups consisting of vitamins, mineral supplements or medicines (including oral rehydrate solution) are permitted.

The advantages of breast milk and breastfeeding far outweigh the advantages of formula feeding by far (WHO, 2012). Breast milk is known to have sufficient nutrients for the infant, is easily digested and efficiently used, protects against infections and is cost-effective compared to formula milk. Breastfeeding is known to increase bonding between mother and infant, helps delay the onset of new pregnancy and protects the mothers' health (Rollins et al., 2016).

Preterm infants are known to suffer from numerous complications. This is due to their immature organs that are poorly suited to the extra-uterine environment at birth. Infants born before 32 weeks of gestational age, are at an even greater risk to these complications, and their risk of morbidity increases. These complications are are known to have an influence on the infant's life throughout childhood and across the lifespan (Gregory et al., 2016). Preterm infants born before 32 weeks of gestational age are at a high risk for intestinal inflammatory conditions, especially necrotising enterocolitis (NEC). Necrotising enterocolitis is known to affect roughly 10% of preterm infants born with a weight of <1500g and is said to be a major factor in neonatal morbidity and mortality (Patel et al., 2015).

Because preterm infants have a history of poorly developed organs, breast milk is strongly recommended as it contains vital developmental and immune-promoting factors such as oligosaccharides and immunoglobulins, needed to protect the infant against excessive intestinal inflammation. The ingestion of breast milk is of specific benefit to the preterm infant especially when given as soon as possible after birth. This is because breast milk has a protective effect against the development of NEC (Gregory et al., 2016).

An exclusive breastfeeding diet provided to the preterm infant is associated with a decrease in length of neonatal intensive care stay and, overall, a decrease in hospitalisation costs compared with providing a partial breastfeeding diet (Tully et al., 2016). Preterm infants receiving more than 50% breastfeeding as enteral feedings have a faster transition to full enteral feeding compared with other preterm infants. Rapid feeding advancements for very low birth weight infants provides a protective barrier against late-onset sepsis and other health problems (Härtel et al., 2009).

Breastfeeding preterm infants need an individualised approach addressing maternal emotional needs, mother-infant interactions, infant behavioural capabilities, infant oral feeding readiness and changes in the above factors over time (Tully et al., 2016).

2.11 FORMULA MILK

Health outcomes vary greatly between mothers and infants who formula feed, and those who breastfeed. Those infants who do not breastfeed are known to have an increased risk of infections, morbidity, childhood obesity, types one and two diabetes, leukaemia and sudden infant death syndrome (Stuebe, 2009). All infant formulas use cow's milk or soya milk as the basic ingredient with supplemental ingredients to further mimic the composition of breast milk. Additional extras added to formula milk such as iron, nucleotides and a variety of fat blends further try to mimic the additional health benefits of breast milk is able to give an infant. Some formula milks also contain additional benefits like probiotic compounds that are genetically engineered into the product (Martin, Ling & Blackburn, 2016). The animal milk present in infant formulas contains more protein than human milk. It is difficult for an infant's immature kidneys to excrete the extra waste from the protein in animal milks. Human milk also contains essential fatty acids that are needed for a infant's growing brain and eyes and for healthy blood vessels. These fatty acids are not present in animal milk but may be added to formula milk (WHO, 2012).

Certain formulas are specialised according to the infant's needs. Relevant to this study is milk specially designed for premature infants. Prematurity is an indication for specialised formula since preterm infants have higher nutritional needs as discussed earlier. Preterm infant formula is indicated for preterm infants whose mothers are unable to breastfeed them for various reasons. Hospitals usually use it for preterm infants smaller than 37 weeks gestational age, and/or weighing less than 2500 g. Preterm formula is only medically indicated and should therefore not be routinely used (Owens, Labuschagne & Lombard, 2012).

All current literature contains very clear evidence regarding prematurity, infant formula and NEC. Necrotising enterocolitis is defined as an acute ischemic necrotising disease of the gastrointestinal tract and mostly affects the preterm infant. Breast milk decreases the incidence of NEC. The incidence of NEC varies between 6-10% in very low birth weight infants admitted to neonatal intensive care units. Existing preterm formulas are manufactured according to the composition of preterm breast milk. Preterm formulas do not contain the necessary non-nutrient components found in breast milk such as secretary IgA, lysozyme, oligosaccharides, PUFAs and platelet-activating factor (PAF)-acetylhydrolase. These components are not evident in formula milk and are needed by the infant to enhance the gastro-intestinal (GI) mucosal integrity, function and strengthen immunity against GI infections (Ramani & Ambalavanan, 2013). A study was done on extremely low birth weight infants enrolled in the National Institute of Child Health and Development Glutamine Trial. The study population consisted of 13% of infants who died or were diagnosed with NEC 14 days post-birth. For every 10% increase in breast milk intake, a decrease by a factor of 0.83 occurred in NEC or death after day 14 (Ramani & Ambalavanan, 2013). Grade A recommendation states that donor breast milk should be used over infant formula in the management of preventing NEC in the preterm infant (Ramani & Ambalavanan, 2013).

The prevalence of preterm death is high and therefore, using the given information about formula milk, it is evident that formula milk is highly discouraged in the vulnerable preterm population. In most cases, preterm formula is only recommended when the infant no longer has a mother, is abandoned or the infant is unable to tolerate breast milk due to galactosaemia (Belfort et al., 2016).

The immune system of preterm infants is exceptionally immature. This means that preterm infants are at an increased risk for serious immune-related complications. Breast milk contains immunologic properties that protect and strengthen the preterm infant's immunity. By providing the preterm infant with breast milk, health professionals' are not only decreasing the risk of infection, but also enhancing neuro-developmental outcomes (Belfort et al., 2016).

With reference to the above information, breast milk is considered as the golden standard for infant nutrition, especially for the preterm infant. With reference to the immunological properties of breast milk alone, it becomes apparent that it has explicit advantages for preterm infants and all infants in general.

2.12 THE UNIQUE BENEFITS OF BREAST MILK TO THE PRETERM INFANT

2.12.1 Clinical advantages

The preterm infant has the inability to defend itself against microbes and to regulate inflammation and wound healing. This contributes to the elevated systemic concentrations of the inflammatory mediators which is a typical characteristic of NEC (Lewis, Richard & Larsen, 2017).

Allergies and other atopic diseases such as asthma, allergic rhinitis and atopic dermatitis are more common in preterm infants. Feeding preterm infants with breast milk is associated with a decreased risk for allergies, including food allergies, asthma and atopic dermatitis (Lewis, Richard & Larsen, 2017).

Broncho pulmonary dysplasia (BPD) is defined as chronic lung disease of the preterm infant after receiving supplemental oxygen, require long-term oxygen usage (Harrold, Ali, Oleszczuk, Lacaze-Masmonteil & Hartling, 2013). This form of lung disease is common in preterm infants and occur in roughly 16-23% of preterm infants. Expressed breast milk is defined as using the hand or a pump to obtain breast milk (Johns, Forster, Amir & McLachlan, 2013). In a prospective multicenter cohort study, EBM was associated with a decreased risk of BPD. It is hypothesised that the protective effect of BM is due to the multiple bioactive components and immunomodulatory factors found in BM (Hair, 2016).

Retinopathy of prematurity (ROP) is a potential blinding disease of the retina. It remains the most common cause of blindness in children in both developing and developed countries (Stahl, Hellstrom & Smith, 2016). It is hypothesized that poor LCPUFA status with a poor regulatory inflammatory response cause ROP pathogenesis. According to a recet systematic review, any exposure to breast milk protects the preterm infant from ROP (Lewis, Richard & Larsen, 2017).

2.13 BREASTFEEDING OF THE PREMATURE INFANT

Preterm infants experience an increase in the length of hospital stay. Apart from medical complications, depending on their gestational age, preterm infants are not always able to progress to oral feeding as instantaneously as term infants.

As previously mentioned in section 2.10 of this chapter, oral feeding is a complex skill requiring integration, maturation and coordination of multiple systems. Due to their immaturity and difficulty in regulating autonomic functions, preterm infants are most likely to have trouble in feeding orally (White-Traut et al., 2013). Prior to discharge from a hospital, a preterm infant need to achieve successful oral feeding.

Suck, swallowing and breathing is the most highly organized requirement needed by the preterm infant. The mouth, palate, pharynx, larynx and oesophagus are all involved. As mentioned in previous sections of this chapter, this coordination occurs roughly between 32-34 weeks of gestational age. Research states that even though infants should be able to successfully oral feed at 32-34 weeks of gestational age, an individualised approach is highly recommended (Lau, 2015). This means that breastfeeding preterm infants, become a challenging task in practice.

2.13.1 Challenges of breastfeeding premature infants

From a lactation point of view, the best way to encourage milk supply is through the suckling of an infant. Preterm infants, as mentioned above, are not all mature enough to suckle on the mother's breast and therefore mothers tend to struggle with breast milk production (Sweet, 2008). The easiest way in which to enhance milk supply is if mothers immediately begin to express directly post-delivery if they are able to do so. This then ensures ongoing lactation as far as possible. Those mothers whose infants are in the neonatal intensive care unit or whose infants are not feeding, need to ensure that they start expressing within the first 6-12 hours of delivery and to express as often as possible and not just for the necessary feeding times. All mothers should empty their breasts whenever expressing as this is another means of ensuring lactation. These are ways in which the dietitian or nurse within the unit ensures that the premature infant receives its mother's milk during every feed (WHO, 2016). In conjunction with poor maternal breast milk production, it is of great importance to note that breast milk does not always cause adequate growth velocity in the preterm infant (Underwood, 2013).

As mentioned previously, preterm milk only remains higher in protein and energy for a few days and therefore is speculated to no longer meet the nutritional needs of the premature infant thereafter (Gidrewicz & Fenton, 2014). This means that additional nutrients are needed to enrich breast milk and this encompasses the reasoning behind breast milk fortification.

2.13.2 Breast milk fortification

Choi et al. (2015) define standard fortification of breast milk as “breast milk with the addition of commercially available human milk fortifier”. Human milk fortifiers are produced from bovine milk to provide the important nutrients lacking for the preterm infant within the breast milk, namely protein, calcium, phosphorous and vitamin D. Rochow et al (2015) and Carlson et al (2011) state that providing fortification to a preterm infant provides enhanced growth of weight, length and head circumference. There is a lack of studies regarding the outcomes of bone mineralisation and neuro-developmental outcomes when using fortification (Choi, Rochow & Fusch, 2016).

To date, there is little to no evidence proving that fortification can improve short term growth without a significant increase in NEC or enhanced long term outcomes. According to Ramani & Ambalavanan (2013), there is some evidence to the contrary stating that fortification of breast milk decreases the incidence of NEC. However, the issue remains that fortification is costly and introduces foreign biological substance.

As per the WHO document regarding the guidelines on feeding low birth weight infants, reported on the impact of multi-component fortification on mortality rates in very low birth weight infants. There was no significant difference in the risk of mortality between those infants who received human milk fortification and those who did not (WHO, 2011). With reference to HIV/AIDS, the importance of exclusive breastfeeding (EBF) should be taken into strict consideration. By definition alone, EBF is known as providing breast milk only from 0-6 months of age without the addition of any fluids, formula milk or powders.

Fortification is seen as medically indicated. Many companies claims that fortification is indicated because preterm infants having higher nutritional needs. But as per the WHO document described above, EBF alone without providing fortification does not increase mortality (WHO, 2016). This then poses the question of whether providing fortification to HIV exposed infants adds to the infants’ risk of contracting HIV. This, however, would be unethical to prove in practice and therefore remains unanswered.

2.14 BREASTFEEDING IN THE CONTEXT OF HIV AND PMTCT

2.14.1 Background

According to the 2016 Mid-Year Population Estimates, the estimated overall prevalence of HIV was 12, 7 % of the total population in SA. The number of people living with HIV was approximately 7.03 million in 2016. For adults within the age category of 15-49 years, 18.9% of the population was HIV positive (Statistics South Africa, 2016).

South Africa has a very low breastfeeding rate among both HIV-infected and uninfected mothers (Mnyani et al., 2017). From 2002-2003, an EBF rate of 10% was reported for HIV exposed and uninfected infants within the first 12 weeks of life (Mnyani et al., 2017). The spread of HIV/AIDS in SA changed the circumstances under which women make decisions about feeding methods, especially with consideration of the mother-to-child transmission of HIV. This led to the introduction of various policies which caused a dramatic shift from breastfeeding to the use of breast milk substitutes (du Plessis et al., 2016). From 2010-2015, multiple changes occurred within infant feeding practices guidelines.

World-wide, a review was done on breastfeeding progress. Over the past few years, SA introduced a review of its commitment to breastfeeding as a component of Infant and Young Child Feeding (IYCF). Currently, the ideal recommendations from the IYCF guidelines stipulate the promotion of EBF for the first six months of life and the continuation of breastfeeding until two years of age and beyond, irrespective of HIV status (WHO; UNICEF, 2016).

The PMTCT interventions in SA were developed for the first time in 2001. Multiple updates have occurred since then with the latest being in 2015. All updates were backed by evidence-based transitions in IYCF recommendations for HIV positive women. The available recommendations changed from breastfeeding and the provision of free commercial infant formula, to the complete avoidance of breastfeeding as long as the given criteria were met (affordability, feasibility, acceptability, sustainability and safety) to breastfeeding under ART cover (du Plessis et al., 2016).

Initially, the first recommendations were for the mother to choose between exclusive breastfeeding up until six months of age or exclusive formula feeding with free formula provided from the state up until six months of age. This meant that breastfeeding was compromised for infants born to HIV positive and HIV negative mothers. This was due to the mixed messages going around and the spill-over effect causing HIV negative mothers to also opt for formula milk (Mnyani et al., 2017). The issue became even more apparent when realising that most mothers live under conditions that do not meet the Acceptable, Feasible, Affordable, Sustainable and Safe (AFASS) criteria and unfortunately, still opt for formula over breastfeeding for fear of their children becoming HIV infected. This caused an even greater deterioration of EBF rates. Mortality statistics were done and indicated that the majority of babies who died were not breast fed (Adhikari & Coutsoudis, 2013).

Although the advantages of breastfeeding were always known, the advantages of breastfeeding in light of HIV/AIDS were uncertain. Breastfeeding initiation rates are high but only a small portion of women decide to exclusively breastfeed for six months and report that cultural factors are the main reason for mixed feeding (Mnyani et al., 2017). Because SA's breastfeeding rates remain low, the South African National Department of Health, Directorate: Nutrition vowed to address the critical state of infant and young child feeding in SA at the highest level of governance. Since then, SA has made good progress in trying to create awareness of breastfeeding by promoting, protecting and supporting exclusive breastfeeding. To improve SA's exclusive breastfeeding rates, barriers to exclusive breastfeeding need to be addressed.

Multiple factors influence a mother's decision to breastfeed her infant. Factors such as a mother's environment play a critical role in her decision to optimally feed her infant and can either support her or hinder her ability to succeed. A mother's family, the community, employers, business, media, hospitals and health services and the state authority or local government, can all play a role due to the policy changes (du Plessis, 2013).

Health care workers play a vital role in a mother's ability to optimally feed her infant (Kassier & Veldman, 2013). Health care workers are the main link between the policy and practice. Clinic staff members, are a critical means of infant feeding information, as indicated by two research studies done in SA, namely, in Mpumalanga province and in the Western Cape, EC and KwaZulu-Natal. These findings state that most mothers based their decision on infant feeding choices on the information that the health care worker provided (du Plessis, 2013). Based on this information alone, it would be logical to conclude that the knowledge of the health care worker regarding infant and young child feeding plays a vital role in the mother's decision to breastfeed. This means that in order to improve SA's exclusive breastfeeding rates, we need to focus on training and retraining of health care workers (du Plessis, 2013).

In light of the poor exclusive breastfeeding rates, the WHO issued new, updated guidelines in 2016 stating the importance of breastfeeding especially in light of HIV/AIDS (WHO; UNICEF, 2016).

Infants who were born to HIV positive mothers and whose infants were receiving exclusive formula feeding (EFF) shown to have a higher incidence of gastro-enteritis, leading to malnutrition and subsequent death (Mnyani et al., 2017). This meant that the risks of exclusive breastfeeding versus exclusive formula feeding became an issue. It was then that the WHO suggested exclusive breastfeeding to be a safer feeding method, especially for mothers and infants living in developing countries, even in the context of HIV. Breast milk is readily available, provided at the perfect temperature for the infant and needs no preparation in order to be received by the infant compared to formula milk. Breast milk is also cheap and incurs no additional costs to the mother. Formula milk demands correct hygiene and sanitation practices, requires boiled water needing electricity, gas or fire, and becomes very costly, especially to those who are not working (Mnyani et al., 2017).

2.14.1 a) Specific nutrition for preterm and LBW infants

Preterm and LBW infants are at a higher risk of perinatal HIV transmission compared with term and normal birth weight infants. Preterm birth, prior to sufficient passive transfer of maternal neutralising antibodies, could cause decreased protection against postnatal HIV infection (National Department of Health, 2015).

The preterm gut differs vastly from the full-term gut. The preterm gut underdeveloped microvilli and brush border enzymes, thus the infant has a higher risk for malabsorption, stasis, bacterial overgrowth and inflammation. The only way to prevent intestinal inflammation and NEC is if the infant is fed breast milk at a slow rate (Kuhn, 2015).

2.14.1 b) Neonates of mothers who are non-adherent or have drug resistant viruses

It is recommended that non-adherent or drug resistant mothers breastfeed as usual. The reason for this is mostly due to poor social circumstances where infants are provided with HIV related care and ARVs as needed; breastfeeding is as important as receiving the correct prophylactic treatment (WHO, 2015; WHO, 2007).

The same considerations for breastfeeding for all HIV exposed infants apply to this group and, since the majority of these infants are born into poor social circumstances; they may suffer from much more severe consequences such as malnutrition and gastro-enteritis if formula feeding is opted for over breastfeeding (Kuhn, 2015).

The risk of HIV transmission is nearly 20 times higher during pregnancy and delivery, than during breastfeeding. Due to the high risk in HIV transmission, it becomes vital that, during pregnancy, ARVs are provided to the mother or infant to help decrease the risks of transmission during during pregnancy, delivery and breastfeeding, by at least 10-fold. Suboptimal adherence to ARVs is still better than receiving no ARVs at all. Formula feeding should only be recommended if all options of access to ARVs for both mother and infant are no longer available, the mother refuses to breastfeed or maternal substance abuse has occurred (Kuhn, 2015).

2.15 EVIDENCE LACKING

The current nutritional management of all preterm infants includes the addition of breast milk fortification to expressed breast milk (EBM) in order to aid adequate weight gain in preterm infants (15 g/kg/day) (Admacher & Adamkin, 2016).

As mentioned previously in this chapter, exclusive breastfeeding rates in SA are extremely low. Mixed messages occur due to constant updates in policies and programmes (du Plessis, 2013). As a result, health care workers who do not receive updated information or who are confused regarding the IYCF policy, relay incorrect messages to mothers. This ultimately means that mothers themselves become confused regarding the safety of breastfeeding in HIV.

Exclusive breast feeding is a critical component of the PMTCT programme. The problem arises with HIV positive mothers who give birth to preterm infants. These preterm infants are HIV exposed.

Bearing this in mind and considering the current nutritional management of LBW preterm infants, the WHO has classified breast milk fortification as “medically indicated” (WHO, 2016). This means that the standard nutritional protocol includes providing all preterm infants with breast milk fortification. By definition alone, as mentioned earlier in this chapter, exclusive breastfeeding requires no other fluids, powders or drinks, but provides an exception to oral rehydrate solution drops and syrups (vitamins, minerals and medicines) (WHO; UNICEF, 2016). Breast milk fortifiers contain extensively hydrolysed proteins produced from bovine milk (Choi et al., 2015). Although breast milk fortification is “medically indicated”, and considering that it contains additional substances and not just vitamins and minerals, the question arises on whether it still constitutes exclusive breastfeeding, and whether a significant decrease in transmission really occurs for HIV exposed infants receiving breast milk fortification.

Currently, literature is available to describe the effect that fortification alone has on the growth velocity of preterm infants but little to no research is available to describe the effect that maternal supplementation and fortification has on the growth velocity of preterm infants.

2.16 SUMMARY

Breast milk is the best source of nutrition for preterm infants. After exploring the current literature and, more specifically, the current situation in SA, the huge impact that nutrition can have on the preterm infant and, more so, the vast difference that adequate maternal nutritional intake has on the nutrition of infants, becomes clear. Nutrition plays a vital role in both mother and infant, especially in preterm infants, and the importance of adequate nutritional intake of the mother and infant needs further attention.

South Africa is known as a developing country associated with poverty. The trends in food security status in SA depict that those experiencing hunger and those at risk of hunger have increased in number from the year 2008 to 2012. Similarly, the number of citizens who are food secure have decreased from 2008 to 2012 (Shisana, 2013).

The health of mothers and their infants is a priority in order to build a firm foundation of good leaders for the country in the future. Naturally, women living in poor economic circumstances have a lack of dietary diversity and these women are most likely to be deficient in MUFAs and PUFAs. This means that macro and micro nutrients needed by the infant are removed from the mother's nutritional stores first after which her body utilizes the remainder nutritional stores for her own normal bodily functioning (Marangoni et al., 2016).

If pregnant and lactating mothers suffer from nutrient deficits, the nutritional composition of their breast milk becomes questionable. Supplementation becomes necessary in order to correct the deficit in costly fats such as MUFAs and PUFAs and to possibly improve on their dietary diversity. It would therefore be logical to incorporate a balanced nutritional supplement including PUFAs and MUFAs to those lactating mothers to improve breast milk quality (Segura, 2016). This ensures nutritional health for both mother and infant.

Lastly, by bearing HIV/AIDS in mind, exclusive breastfeeding is vital to reduce the impact of PMTCT and enhance the immunity and the growth and development of the preterm infant. Just by adhering to exclusive breastfeeding, health professionals able to prevent further transmission of HIV in SA, achieve the recommended growth and development, possibly enhance exclusive breastfeeding rates and decrease the cost of lengthy hospital stay for the preterm infant.

Good growth velocity at an early stage is a critical part of ensuring catch-up growth in low birth weight and preterm infants. Nutritional recommendations propose that preterm infants' growth velocity mimic the growth rate of a healthy unborn foetus, as also recommended by Fenton et al. when they stated that preterm infants' growth should be similar to that of a healthy full-term infant after 40 weeks of gestational age (Fenton et al., 2013). Adequate growth velocity is important for the preterm infant to thrive, to prevent complications, and to prevent future malnutrition and its associated negative effects.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

Growth velocity is a measurement used in neonates to determine the growth rate of preterm infants. This study used growth velocity as a means of determining successful growth in low birth weight preterm infants receiving breast milk from mothers who received supplements, and/or breast milk with fortification. This chapter describes the study design used, the study population and sampling thereof, the methodology used, and the standard protocols which included the supplementation and fortification of breast milk. The chapter further includes the statistical analysis, validity, reliability and relevant ethical considerations adopted during the research project.

3.2 STUDY DESIGN

This was an analytical, observational, longitudinal study. The observational study consisted of a cohort group. The study used quantitative, empirical data. The design was chosen because the researcher aimed to compare weight gain, expressed as growth velocity, with three exposures, i.e. with the use of maternal supplementation and/or breast milk fortification, both currently used as part of standard practice, or a combination of the two. The cohort sample was chosen as the researcher monitored growth velocity of low birth weight preterm infants during the period of hospitalisation and also sought to compare the growth velocity between maternal supplementation and or breast milk fortification groups as an outcome.

3.3 STUDY POPULATION

The population included in this study were any hospitalised low birth weight preterm infants in the Nelson Mandela Bay district.

The research took place at Dora Nginza Hospital (DNH), Zwide, Port Elizabeth. Zwide is separated into four areas labelled as Zwide 1-4. The entire Zwide, including all sub areas, is roughly 4.74 km^2. The total population consists of 39915 people of which 97.8% are Black African. Of the total population, 91.678% speak isi-Xhosa as their home language (Census, 2011). Dora Nginza Hospital is a 570 bed regional hospital. The hospital also serves as a teaching hospital. Dora Nginza Hospital serves has a large influx of patients. The hospital is a government hospital and struggles with financial constraints. Due to financial constraints, the hospital does not always provide nutritionally balanced meals to the patients. Preterm infants in need of medical management (such as antibiotic treatment, ventilator support) are placed in the premature baby unit. Their mothers reside in a separate ward close to this unit until their infants are medically stable and are only still to reach the weight goal of 1.6 kg. Once preterm infants are medically stable and awaiting their weight goal of 1.6 kg, both mother and infant are transferred to a ward for the Kangaroo Mother Care (KMC). Both wards consist of beds and a ward kitchen. The mothers receive three meals on a daily basis. Any additional food need to be purchased independently. All of the above forms part of the neonatal unit at Dora Nginza Hospital.

3.4 SAMPLING

The sampling was purposive and convenient which constituted a form of non-probability sampling. Breastfeeding mothers of low birth weight infants who had not gained adequate weight for discharge within two days of birth were invited to participate. After providing informed consent, they were included in the sample and received maternal supplementation and/or breast milk fortification in order to ensure that the infant thrived as necessary. It was envisaged to include a minimum of 30 participants per nutrition support group.

Study participants were identified at the premature baby unit at Dora Nginza Hospital within the Nelson Mandela Bay health district.

3.4.1 Inclusion and exclusion criteria

The inclusion and exclusion criteria chosen for the study were as follows:

Inclusion criteria:

- All hospitalised, low birth weight, preterm infants receiving breast milk;
- Mothers gave informed consent for participation; and
- Male and female preterm infants.

Exclusion Criteria:

- Infants who gained weight adequately on breast milk alone and thus were soon to be discharged;
- Infants who were transferred to other district hospitals; and
- Infants who died.

3.5 METHODS

3.5.1 Research instruments

Scales

The weight of infants was used as a measure of weight gain. Weight was measured and monitored using a Seca Art no: 3541317009 with max load of 20kg. Measurements were taken in grams. These scales were used by trained staff in the premature baby unit at Dora Nginza Hospital as the preferred infant scale to monitor growth.

A Seca model 7862021994 scale was used in order to perform weight measurements on the mothers. Weight was measured in kilograms. The capacity of the scale was 150 kg.

Stadiometer

A Seca stadiometer model 213 was used to measure the height of every mother in order to determine the BMI. The WHO defines BMI as a person's weight in kilograms divided by the square of his height in meters (kg/m^2) (WHO, 2016). BMI is considered the most useful tool to measure overweight and obesity as well as underweight (WHO, 2016). The BMI was therefore used in order to determine the general nutritional status of the mother and to access how it could potentially affect the infant's weight gain from the breast milk produced.

The BMIs were classified for mothers as depicted in Table 3.1 below ("Obesity and overweight", 2018):

Table 3.1: WHO BMI classification (kg/m2) (“Obesity and overweight”, 2018)

BMI	**Nutritional Status**
<18.5	Underweight
18.5-24.9	Normal Weight
25-29.9	Pre-Obesity
30-34.9	Obesity Class 1
35-39.9	Obesity Class 2
>40	Obesity Class 3

Birth weight and length of infant

Birth weight and length were a measurement done by the nursing staff at DNH. This measurement did not form part of this study as it was a measurement performed outside of the premature baby unit. This measurement was therefore not controlled in the study and its accuracy and precision cannot be accounted for.

Monitoring sheet

A monitoring sheet was attached to the questionnaire to monitor the weight gain in the infant. An example of the monitoring sheet can be found in Addendum A. Each data collection sheet was marked with a date and the participant number. The participant number was a three-coded digit to identify a participant, to prevent confusion and maintain anonymity. The monitoring sheet consisted of a column containing a record of the amount of weight in grams. A growth velocity column was available for the researcher to calculate the growth expressed in grams per kilogram per day (g/kg/day). This column enabled the researcher to determine whether the infant had achieved the adequate growth velocity of 10-15 g/kg/day or not. The growth velocity was recalculated by the statistician during data analysis to verify the results. The monitoring sheet also contained information regarding the type of supplementation given and how much the infant or mother took in on a daily basis. The monitoring sheet contained a column for calibration in order to remind the researcher to calibrate the scale on a daily basis.

Data collection sheet

A data collection sheet was designed for the purposes of this study. An example of the data collection sheet can be found in Addendum A. This tool was printed on A4 paper and was in the form of a table. Each data collection sheet was marked with the date and each study participant received a three-digit code based on numerical values. The data collection sheet required details of the mother and infant. All information was accessed from the file, except for weight and height of the mother. The weight, height and BMI of the mother were taken on the same day that informed consent was given. As seen in Addendum A, the data collection sheet enabled recording of the mother's ethnicity, age, number of infants, HIV status, breastfeeding history, chronic history and social information. The information regarding the infant, recorded on the data collection sheet, included date of birth, birth weight, length and head circumference, medical diagnosis and whether the participant planned to exclusively breastfeed or not.

3.5.2 Pilot study

A pilot study was conducted on five patients in order to ensure that the proposed study occurred with accuracy and precision. The tools tested included the demographic questionnaire and anthropometry in order to identify possible errors that could occur when conducting the research. Patients in the pilot study were excluded from the final sample. Results from the pilot study indicated that no amendments were needed. No changes were made to the methods of the study.

3.5.3 Study procedures

A data collection sheet was completed by the principal researcher. Details regarding the data collection sheet can be found in addendum A. The principal researcher gathered all information needed to complete the data collection sheet, as seen in addendum A. The researcher then conducted all necessary anthropometrical measurements such as weight and length of the mother. All information on the data collection sheet was collected after written informed consent was received.

To accurately measuring anthropometric information in infants and young children followed procedures as described by the Centre of Disease Control (CDC) (2007) and WHO (2006) were followed. Nursing staff had prior training from the Dietetic

Department on anthropometry. The researcher reinforced information regarding how to weigh infants and how to ensure accuracy via retraining.

Data was collected over a period of eight months starting in November 2016 and ending in August 2017. All infants and caregivers who met the inclusion criteria and who provided written and oral informed consent were given a three-coded number on their collection sheet. Standardised and calibrated measuring equipment were used to do weights on the infant. Infants who were placed in the Kangaroo Mother Care ward were measured daily and those who were in normal premature baby units were weighed on Mondays and Thursdays as per hospital policy. This process was repeated until discharge from the hospital. Anthropometric and demographic data was recorded on a monitoring sheet and captured on Excel spreadsheets.

3.5.3.1 Measuring techniques

Study participants were weighed and measured using standardised techniques outlined by CDC 2007 for determining recumbent height and weight.

Procedures for accurate anthropometric indicators were followed in order to ensure reliability of data. Infants were weighed using standardised techniques as stipulated by the CDC (2012) for assessing weight. The scale was placed on a sturdy immobile surface area. The infant's caregiver removed all the outer clothing including the diaper. Prior to performing measurements, the nursing staff or researcher ensured that the scale was calibrated and set to grams. The nursing staff or researcher then turned on the scale and placed a clean Chux pad on the scale. The infant was then placed on the centre of the scale and weight was recorded once the reading on the scale stabilised. Measurements were directly taken and recorded in the infant's file to the nearest 0.1 grams (g).

Mothers were weighed using a Seca model 7862021994 with a maximum load of 150 kilograms (kg). Weight measurements for the mothers were measured in kilograms (kg). Prior to weight measurement, the researcher ensured that the scale was calibrated by placing a known weight onto the scale. Correlation of the scale and the known weight guaranteed scale accuracy. Once calibration was done, weight measurement commenced. The mother was instructed to remove all extra clothing such as shoes, hats, gowns etc. The mother was then instructed to climb onto the centre of the scale, hands at the side of her body whilst the researcher stood behind her and recorded the measurement. The researcher had to ensure that the measurement was taken whilst the mother looked straight ahead of her. Weight was taken to the nearest 0.1 kg (NHANES, 2012). Maternal weight was only recorded once upon entry into the study and therefore not monitored on a regular basis.

The height measurement of the mother was taken using a Seca model 213 stadiometer. The researcher had to ensure that the mother removed any head gear and shoes. The mother then turned her back towards the base of the measuring rod with her body weight evenly distributed on both feet. The mother stood in an erect position with her arms hanging freely at the sides of the body whilst ensuring that the palms faced towards the thighs and the legs were placed together. The head had to face straight ahead. Once the mother was in position, she had to inhale, and height measurement was taken at maximum inspiration. The headpiece was brought down towards the upper-most point of the mother's head. Height was recorded to the nearest 0.1cm (NHANES, 2012).

Nursing staff were given training and retraining throughout the duration of the study to ensure accuracy of data collection. All measurements were repeated thrice in order to ensure further precision. The mean of the three measurements was used.

3.5.3.2 Nutrition management

Considering that this study was an observational study, the nutritional management of infants participating in this study adhered to the current nutritional protocol in the neonatal unit. Nutrition management occurred from entry into the study and continued until discharge from the hospital.

Adequate growth velocity

At Dora Nginza Hospital, the dietetic department staff measure the growth of preterm infants and expressed that as growth velocity in grams per kilogram per day (g/kg/day). Various other methods exist such as weight gain in grams per day or growth in centimetres per week. Fenton et al. (2017) did a study on preterm infant growth velocity calculations and found that in the majority (40%) of studies growth velocity (g/kg/day) is used. The following calculation was used:

New weight (g) - previous weight (g) ÷ previous weight (kg) ÷ number of days between new weight and previous weight

Adequate growth velocity is variable in preterm infants. According to Fenton et al. (2017), preterm infants' growth rates after delivery differ according to gestational age, with weight velocity decreasing to 5 g/kg/day at 50 weeks gestational age Fenton et al. (2013) recommends a safe and adequate growth velocity ranging between 10-15 g/kg/day (Fenton et al., 2013). Therefore, as per DNH protocol, for the purpose of this study, adequate weight gain was been chosen as 15 g/kg/day as chosen from the range between 10-17 g/kg/day.

Nutritional management at DNH

Dora Nginza Hospital's nutritional management of low birth weight infants consists of extensive lactation counselling prior to giving any sort of supplementation. Optimal growth velocity in the preterm infant is one of the main nutritional goals. Table 3.2 below describes the growth velocity categories and birth weight categories used in this study. With reference to table 3.2, if an infant receiving breast milk had poor growth velocity, maternal supplementation was given in the form of an oral drink providing additional fats to the mother's breast milk.

Table 3.2: Birthweight & growth velocity classification (UNICEF, WHO, 2004)

CATEGORY	CLASSIFICATION
a) BW (g)	
Low birth weight (LBW)	<2500
Very low birth weight (VLBW)	<1500
Extremely low birth weight (ELBW)	<1000
b) GROWTH VELOCITY (g/kg/day)	
<10	Poor
10-15	Adequate
>15	Good

Breastfeeding counselling and education was given as a means of standard nutritional management at DNH regardless of supplementation. Breastfeeding counselling is critical to every breastfeeding mother in order to ensure lactation and to improve weight gain in low birth weight and preterm infants (Lauwers & Swisher, 2016). Infant participants who entered the study with a weight loss, received BM fortification with the expressed breast milk. Addendum C summarises the nutritional protocol followed at DNH. As illustrated in addendum C if, after receiving the BM fortification with the expressed breast milk, the infant failed to thrive with an adequate growth velocity of 10-15 g/kg/day on any weigh-in day, the infant received an additional form of supplementation via maternal supplementation. Although the researcher originally envisaged two groups only, it was adapted to three groups because infants were not thriving according to expected growth velocity mentioned above. From an ethical point of view, additional supplementation could not be withheld and therefore the third supplementation group was created.

Nutritional composition of supplementation provided to sample

Maternal supplementation was provided to the breastfeeding mothers. Ensure, provided in a 400g tin was provided to mothers as part of the protocol at DNH. If a stock of Ensure was no longer available, Excel sachets of 50g was provided to mothers. Mothers prepared their own supplementation at ward level and consumed this twice daily.

Table 3.3 summarises the macronutrient composition of the provided supplement. The supplement was selected solely according to the most applicable product available on tender to the hospital i.e. the products selected contain PUFAS and are branded as 'standard supplementation' according to the Recommended Daily Allowance (RDA). Nutritional supplementation varied according to availability of stock. Table 3.3 below describes the macronutrient composition of two available nutritional supplements at DNH.

Table 3.3: Macronutrient composition of available nutritional supplements at DNH

Macronutrients	**Ensure** **230ml per serving**	**Excel** **50g sachet per serving**
Energy (kcal)	230	196
Protein (g)	8.6	8
Total Carbohydrates (g)	33.2	27.5
Fat (g)	7.5	5
PUFA (g)	1.6g	1.6g
Omega 3 (g)	0.2g	0.25g
Omega 6 (g)	2.2g	2.25

Breast milk fortification was provided to caregivers. FM85 is currently the only available breast milk fortifier available in SA. Mothers received FM85, provided in the form of one gram satchets, to mix into 25ml EBM per three hourly feed as indicated. This formed part part of the nutritional protocol at DNH. The nutritional composition of FM85 is illustrated in Table 3.4

Table 3.4 : Macronutrient composition of breast milk fortification at DNH

Macronutrients	**Per 100g powder**	**Per 1g FM85**	**Per 100ml as consumed**
Energy (kcal)	435.0	4.4	85.0
Protein (g)	35.5	0.4	3.0
Carnitine (mg)	66.0	0.7	3.3
Taurine (mg)	50.0	0.5	6.0
Carbohydrates (g)	32	0.3	9
Of which Lactose (g)	0.0	0.0	7.1
Maltodextrin (g)	28.8	0.3	0.3
Fat (g)	18.1	0.2	4.2
Omega 6 (mg)	838.3	8.4	513.6
Omega 3 (mg)	390.9	3.9	45.6

3.5.3.3 Data Categories

The raw data was divided into clusters according to various categories. Infant participants were divided into male and female. The sample was further clustered into birth weight categories as seen in Table 3.2. Participants with a birth weight of less than 2500g were classified into the low birth weight category. Participants with a birth weight of less than 1500g were classified into the very low birth weight category and participants weighing less than 1000g are classified as extremely low birth weight (WHO, 2016). Maternal age and BMI were classified, and the classification information can be found in Table 3.5. Maternal age was clustered according to age and risk of preterm birth i.e the younger and older mothers. As seen in table 3.5, three age clusters were formed and categorised. Mothers who were younger than 20 years old were seen as a high risk to preterm birth, mothers between the ages of 20 and 35 were categorised as normal risk and mothers older than 36 were also categorised as high risk (Waldenström et al., 2016). Furthermore, as mentioned above, the BMI was categorised as illustrated in table 3.5. Anthropometrical findings of growth velocity were clustered and categorised. This can be seen in table 3.2. Growth velocities of less than ten were classified as poor growth velocity, growth velocities of 10-15 g/kg/d were classified as adequate and growth velocities of more than 15 g/kg/day were seen as good growth velocities (Fenton et al., 2013).

Participants were further categorised into various birth weights, i.e. low birth weight, very low birth weight or extremely low birth weight. Birth weight is an important factor to consider as it is known as one of the important determinants of perinatal survival, infant morbidity and mortality. Birth weight also determines the infant’s risk of developmental disabilities and illnesses in the future (Gebregzabiherher et al., 2017). Table 3.2 provides the various birth weight categories. Low birth weight infants were categorised as having a birth weight of <2500g, very low birth weight was categorised weighing <1500g and extremely low birth weight infants were classified weighing <1000g (UNICEF & WHO, 2004). All health care professionals working in the neonatal unit were allowed tof refer preterm patients with insufficient growth velocity.

Table 3.5: Maternal age and BMI categories (WHO,2017)

MATERNAL BMI		**MATERNAL AGE (years)**	
UNDERWEIGHT	<18.5	HIGH RISK	<20
NORMAL	18.5-24.9	NORMAL	20-35
OVERWEIGHT	25-29.9	HIGH RISK	36+
OBESITY	>30		

3.6 ANALYSIS

This study determined the anthropometrical data of growth using growth velocity calculated in grams per kilograms per day. Infants were then categorised according to three different categories of growth velocity as seen in Table 3.2.

This study used descriptive statistics, ie frequencies and percentages to present categorical data and means and standard deviations to present numerical data.

Relationships were illustrated by determining associations using the chi-square (Chi^2) test. The chi-square is a statistical test used in research in order to highlight the importance of a relationship between two categorical variables (Dawson & Trapp, 2005). This test was used in the proposed research to investigate whether an association was present between maternal risk factors and birth weight (BW) outcomes. A p-value of 0.05 was considered to be statistically significant.

Limitations to Chi-square were considered; two limitations exist. The chi-square test is sensitive to sample size. This means that statistical significance does not necessarily provide meaningful results. The second limitation is that chi-square is only able to report on whether two variables are related to one another. Therefore, chi-square does not imply that one variable necessarily has any causal effect on the other. Establish causality requires a more detailed analysis (McHugh, 2013), and a different study design.

Analysis of variance (ANOVA) can be defined as a statistical procedure used to determine whether any differences are present amongst two or more groups of subjects on two or more subjects on one or more factors. The F test was used in ANOVA (Dawson & Trapp, 2004). Analysis of variance (ANOVA) was used in order to determine whether there were any differences in growth velocity and certain risk factors within the various proposed intervention groups.

The Scheffe procedure is known as a post-hoc test. This test is useful to test for significant difference between two treatment conditions used. This procedure uses a multi-comparison method to compare means following a significant F test in the ANOVA (Dawson & Trapp, 2005). This is also known to be the most conservative multiple-comparison method. In this study, the post-hoc test was done to compare the growth velocities and number of days on treatment with the various nutritional interventions used in the study.

Cohens *d* is a method used in statistics in order to measure an effect size. By measuring the effect size, researchers can determine the magnitude of the treatment effect despite the sample size used. Therefore researchers can indicate the standardised difference between two means. This helps to accompany ANOVA results (Dawson & Trapp, 2005). Cohens *d* was used in addition to ANOVA to determine the effect that growth velocity and days had on the various nutritional interventions tested in the study.

3.7 VALIDITY AND RELIABILITY

3.7.1 Validity

Validity determines the degree to which a measurement measures what it intends to measure (Bolarinwa, 2015). Various types of validity exist in research, of which face validity and content validity was used in the study.

Face validity

Face validity occurs when a researcher reviews a questionnaire for a specific subject and ensures that the questionnaire measures the characteristic or trait of interest (Bolarinwa, 2015). Face validity was strong within the study as the anthropometric measurements used in the study were part of current routine growth monitoring and promotion used in paediatrics as recommended by WHO. The BMI interpretations of adults were used on mothers and form part of existing screening for malnutrition as per WHO guidelines. All instruments used in the study were calibrated daily and measurements were taken thrice to further ensure face validity.

Content validity

Content validity refers to the degree in which an instrument fully assesses or measures the subject of interest (Bolarinwa, 2015). Standard measuring equipment was used to perform anthropometry. Infant and adult scales were used to measure weight as recommended by WHO (2006). A stadiometer was used in order to measure the height of mothers as per WHO (2006) recommendation. Staff members were trained and retrained using the CDC 2012 standardised techniques. This is an official document that was proposed to reduce errors of communication or uncertainty.

3.7.2 Reliability

Reliability can be defined as the degree of accuracy to which the results of a measurement and procedure can depend on (Bolarinwa, 2015).

Weight was measured using the same equipment in order to ensure precise consistency. The data collection sheet and measuring techniques were ensured by the pilot test performed prior to the commencement of the study. This was a way in which to ensure precision in the data collected. All supplementation was monitored and recorded in the medical nursing charts as part of standard nursing observations practiced at DNH. The researcher provided the mother with the exact amount of fortification needed for the week in order to ensure that only the prescribed amounts were used. Maternal supplementation was monitored by the researcher and the nursing staff. One tin of powdered oral maternal supplement made 7 servings. Calculations were based on the amount prescribed per day. For example, if the mother was instructed to consume maternal supplementation twice a day and ran out of supplement by the second day, then the mother was not doing as instructed and was excluded from the study. Mothers were taught how to mix supplementation according to labelled instructions advised by the manufacturer.

Internal reliability

Internal reliability refers to the extent to which items on the test or instrument measured produce the same scores (Bolarinwa, 2015).

This study made use of few fieldworkers. Nurses already weighing infants on ward level, and who were trained, were chosen to perform weighing of infants. This ensured that consistency was used in measurement accuracy. The same measuring instruments were used throughout the study. The same measurement instruments were used in order to perform maternal weight and height. This was done by the researcher throughout the entire study using the same equipment for all mothers.

3.8 ETHICAL CONSIDERATIONS

The research project was submitted to the Nelson Mandela University Research Ethics Committee (Human) for ethical approval as the research is based on a vulnerable population. Once approval was received, the study was registered at the National Health Research Database, and the Eastern Cape Department of Health ethics committee granted the researcher an approval number EC_2016RP27_564 (Addendum D). Permission was further granted by the Department of Health (Addendum E) and then by the clinical governor of Dora Nginza Hospital to be able to perform the study at Dora Nginza Hospital (Addendum F). The principal researcher was obligated to inform the head of neonatology, the registered nurse in charge of the unit, and the head of dietetics, as the research affected all parties.

Once consent was given by the relevant gatekeepers, the researcher started to invite participants and obtain informed consent (Addendum G). Participation in the study was voluntary. Informed consent can be defined as a decision to be included in research, by an individual who has been given adequate information about the study, who has properly understood the conveyed information and who, after considering the information, has come to the conclusion without being subjected to coercion, influence, inducement or intimidation (WHO, 2002). Informed consent is a vital part of adhering to ethical principles and rightfully respecting an individual and, thus, all necessary information of the study was fully explained in layman's terms. Information was conveyed orally first in English and or Afrikaans. Caregivers who did not understand either language, communicatd through an interpreter (mostly Xhosa). Written informed consent was obtained after oral informed consent and data collection commenced thereafter. All questions raised were answered honestly and sufficient time was given for the individual to make a decision. Informed consent was received and therefore, in doing so, leads to respecting the dignity and autonomy of the individual. All information will remain anonymous and all participants received a three-digit identification code in order to ensure anonymity. All information needed by the researcher was acquired through non-invasive questions.

Beneficence is described by the Council for International Organizations of Medical Sciences (CIOMS) as the ethical obligation to maximize benefits and to minimize harm (WHO, 2002), whilst non-maleficence is described as “to do no harm”. The researcher ensured that all infant and caregiver pairs participating in the study were given proper care regardless of whether or not they decided to enter the study. All hospitalized patients received the same care as per hospital protocol and therefore were not exposed toany harm or injury. All research in the study was safe therefore adhering to beneficence and non-maleficence and justice. All caregivers of infants who participated in the study received feedback on the infants’ weight gain or weight loss and possible reasons for this. All the above-mentioned factors are in line with the core ethical principles and philosophies of human rights.

The ethical principle of justice was adhered to as the researcher is a registered dietitian registered with the Health Professions Council of South Africa (HPCSA) with experience in counselling. All mothers were treated fairly and counselled were according to the needs of the individual.

There are no known conflicts of interest to declare.

3.9 CONCLUSION

This chapter described the design of the study and the exact methodology used. Chapter three touches on the nutritional management used at DNH and the procedure that the study followed. Validity and reliability are important measures to ensure scientifically sound research and was covered in this chapter. Ethical considerations used in this study are explained.

Results obtained will be presented in chapter four.

CHAPTER 4

RESULTS

4.1 INTRODUCTION

This chapter describes the demographic information of the study sample. The results are further presented according to maternal risk factors, growth velocity outcomes according to supplementation group and the number of days that the supplementation continued before discharge was possible. The associations between maternal risk factors and BW groups are explained in detail by providing chi values wherever possible. Statistical significance ($p<0.05$) is highlighted in order to emphasise the importance of the results. In Chapter 4, furthermore, the researcher presents the growth velocity outcomes according to the various supplementation groups in the sample.

4.2 DESCRIPTION OF THE STUDY SAMPLE

4.2.1 Demographics

A total sample size of 91 LBW preterm infant and mother pairs were included in the study. One set of quadruplets were included into the sample size, one set of triplets and one set of twins; thus making the total number of mothers included in the sample size, 88. Originally, two participants were excluded from the sample. One of the participants demised and the other participant refused informed consent.

4.2.1.1 Maternal information

a) Age

The total sample size of the mothers was 88. The mean age of mothers was 26 years old (SD=7.25). Maternal age ranged between 16 and 43 years of age. The age of mothers (years) were categorised into three i.e. ages <20, 20-35 and 36 and above. Maternal age categories were described in chapter three and illustrated in table 3.5. As summarised in table 4.2.1, 64% (n=58) of mothers fell into the age category of 20-35 years, 20% (n=18) fell into the age category <20 years, whilst 16% (n=15) of mothers were either 36 years or older. Of the total sample 35% could therefore be categorised in “at risk” age categories.

b) Ethnicity

Of the total sample, 54% (n=49) of participants were of coloured ethnicity and 46% (n=42) of participants were of black ethnicity.

4.2.1.2 Infant information

a) Gender

The sample consisted of 58% (n=53) male infants and 42% (n=38) female infant participants.

b) Birth weights (BW)

The mean BW in the study sample was 1268.02g (SD=288.05). Figure 4.2.1 illustrates the distribution of the various BW categories in the sample. The BW's in the study sample ranged between 600g and 1950g. The median weight of the sample the sample size was 1220g. Of the total sample (n=91), 65% (n=59) were VLBW, 22% (n=20) were LBW and 13% (n=12) were ELBW infants.

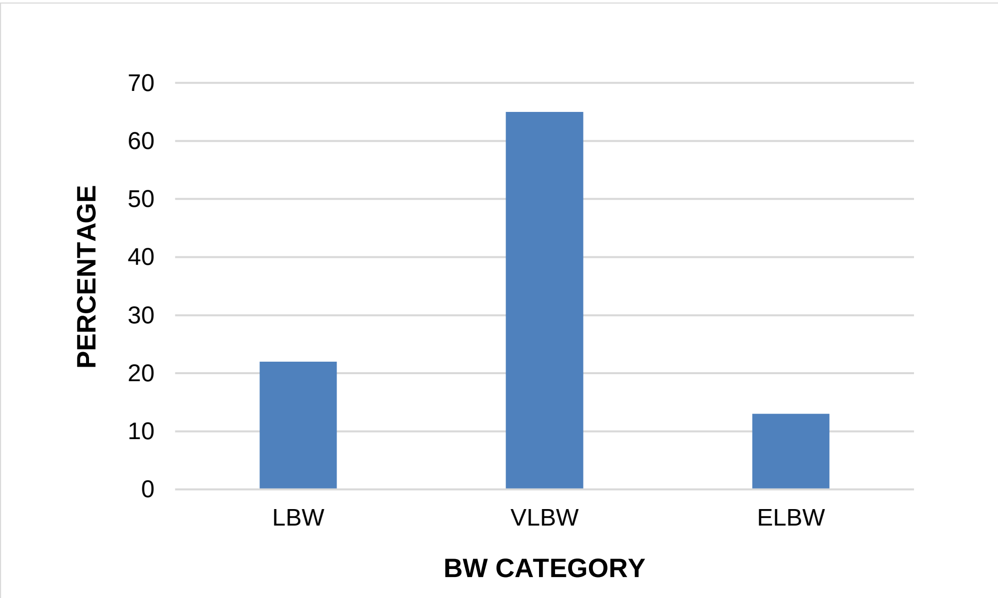

Figure 4.2.1 BW category in the study sample (n=91)

4.2.2 Maternal disease history

The maternal disease history of mothers in the sample (n=88), is illustrated in Table 4.2.1 and Figure 4.2.2.

Within the total sample of mothers (n=88), 34% (n=31) were HIV positive, whilst 66% (n=60) of mothers were HIV negative. Subsequently, 35% (n=31) of mothers who were HIV positive gave birth to infants who were HIV exposed, while 65% (n=60) of infants born were HIV unexposed. Of the sample (n=46), 65% (n=30) of mothers were diagnosed with hypertension. Of the sample size (n=46), 35% (n=16) of mothers had no chronic diseases.

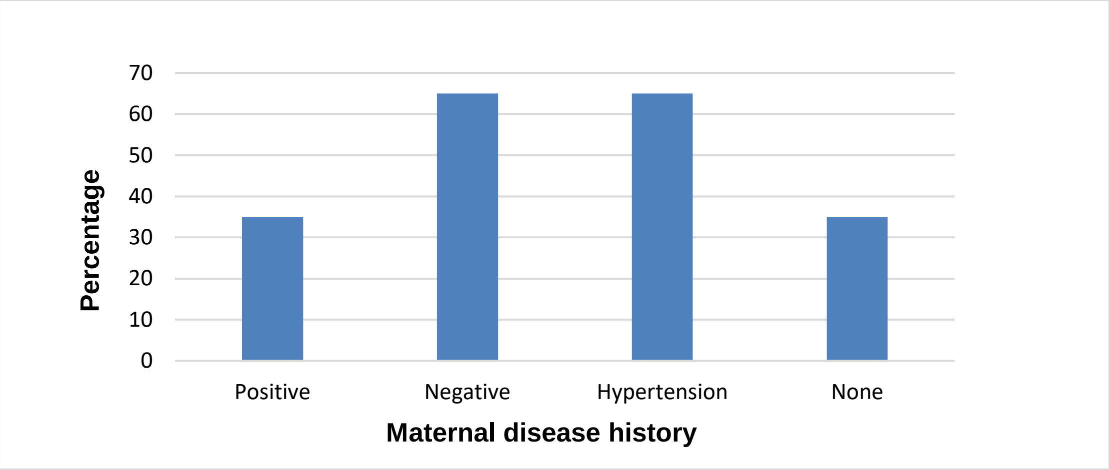

Figure 4.2.2 Maternal disease history

4.2.3 Maternal nutritional status

In order to measure the nutritional status of mothers, the BMI categories were used. (Table 4.2.1)

4.2.3.1) BMI

Of the total sample of mothers (n=88), the mean BMI was 24.30 kg/m^2 (SD=4.76). The BMI ranged between 16.59 kg/m^2 and 40.36 kg/m^2. Of the total sample (n=88), 61% (n=54) of mothers were normal weight, 23% (n=20) were overweight and four percent (n=4) were underweight.

4.2.3.1a) Supplementation categories according to BMI

Of the underweight mothers (n=4), 50% (n=2) received BM fortification only, 25% (n=1) received maternal supplementation only and the remainder 25% (n=1) received maternal supplementation and BM fortification.

4.2.4 Maternal social behaviour

The social behaviour of mothers is important as it could possibly affect the risk to prematurity and development of the infant. This is further illustrated in Table 4.2.1.

Of the total sample (n=90), 18% (n=16) of mothers reported to smoke, whilst 82% (n=74) of mothers did not smoke. Seven percent (n=6) of mothers in the sample reported to consume alcohol, whilst 93% (n=85) of mothers reported to consume no alcohol at all. Only 3% (n=3) of mothers reported to using recreational drugs; 97% (n=88) of mothers reported using no drugs at all.

Table 4.2.1: Associations between maternal risk factors and BW categories (n=88)

RISK FACTOR		TOTAL		LBW		VLBW		ELBW			
		n	%	N	%	n	%	n	%	Chi^2	p
1.AGE & ETHNICITY											
Age	<20	18	20	4	22	14	78	0	0	8	0.09
	20-35	58	64	12	21	34	59	12	21		
	36+	15	16	4	27	11	73	0	0		
Ethnicity	Coloured	49	54								
	Black	42	46								
2. CHRONIC DISEASES											
HIV	Positive	31	34	8	26	28	58	5	16	0.95	0.62
	Negative	60	66	12	20	41	68	7	12		
Hypertension	Yes	31	34	5	16	19	61	7	23	7.46	0.28
	No	60	66								
3. NUTRITIONAL STATUS											
BMI	Underweight	4	4	2	50	2	50	0	0	10.89	0.09
	Normal	56	62	12	21	38	68	6	11		
	Overweight	20	22	3	15	15	75	2	10		
	Obese	10	11	3	30	3	30	4	40		
4. SOCIAL BEHAVIOUR											
Smoking	Yes	16	18	4	25	11	69	1	6	0.86	0.65
	No	74	82	16	22	47	64	11	15		
Alcohol	Yes	6	7	1	17	4	67	1	17	0.14	0.93
	No	85	93	19	22	55	65	11	13		
Drugs	Yes	3	3	1	33	2	67	0	0	0.59	0.74
	No	88	97	20	22	59	65	12	13		

4.3 THE RELATIONSHIP BETWEEN MATERNAL RISK FACTORS AT DORA NGINZA HOSPITAL WITH LBW CATEGORIES

Maternal risk factors are important to take into consideration as there could be a possible association between certain maternal factors and the prevalence of prematurity. The associations between the various BW categories of infants and maternal risk factors were tested by using the chi-square test of independence. Table 4.2.1 illustrates the associations between maternal risk factors tested and LBW categories.

4.3.1 Maternal age

The age categories <20 years old and older than 36 years of age are considered risk factors to premature birth. Since a large proportion of LBW infants were excluded from the general growth velocity outcomes, because most of these infants generally had a short length of hospital stay and they do not have to wait for a discharge weight of 1600 g, the study sample was not representative of the LBW population in NMB health district. The results described here should thus be interpreted in that context. From this sample (n=88), 65% of mothers (n=59) gave birth to VLBW infants (figure 4.3.1). Of the infants who were born VLBW (n=59), 24% (n=14) was born to mothers <20 years old and 19% (n=11) was born to mothers older than 36 years. In total, 42% (n=25) of mothers who gave birth to VLBW, fell in the "at risk" age categories. All the ELBW infants were delivered by women between 20 and 35 years of age. Quadruplets and twin pairs were included into this sample, however, did not form part of this ELBW group. Out of the total LBW infants (n=20) in the sample, 60% (n=12) were born to mothers in the 20-36 year category. Most LBW infants fell in this age category. The association was however, not statistically significant, and therefore in this study maternal age was not associated with BW.

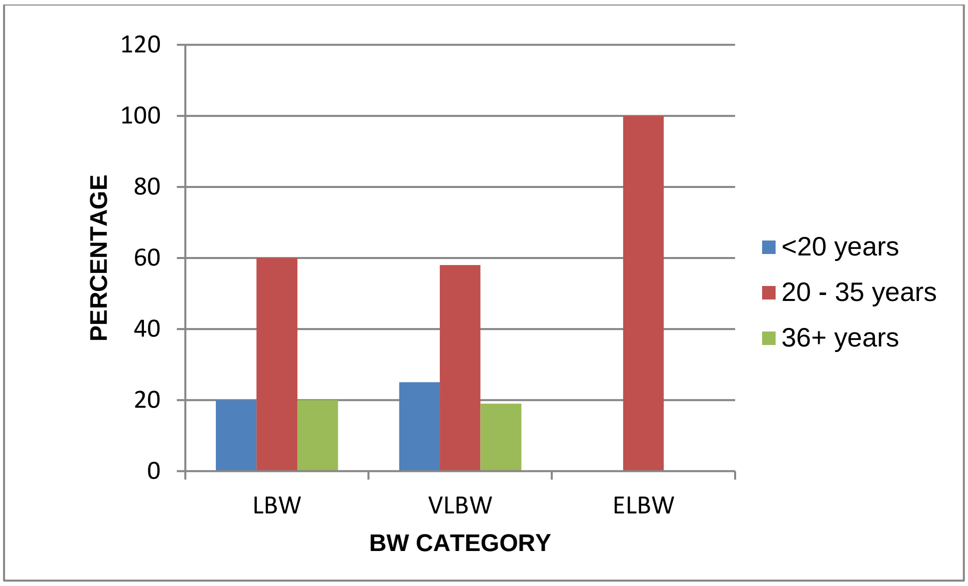

Figure 4.3.1: Maternal age category by BW category

4.3.2 Nutritional status

Nutritional status is always an important indicator to determine general health. For this study, BMI was used to determine maternal nutritional status. As mentioned in 4.2.3.1, 61% (n=54) of mothers were normal weight, 23% (n=20) were overweight and four percent (n=4) were underweight. Figure 4.3.2 depicts four various BMI categories. Any category below, or above normal BMI, is a risk factor to under or over nutrition. Of the women in the obese category (n=10), 40% (n=4) gave birth to ELBW infants. Of the overweight mothers, 75% (n=15) gave birth to VLBW infants. Half of the underweight mothers, 50% (n=2) gave birth to LBW infants, while the remainder 50% (n=2), gave birth to VLBW infants. No significant associations could be demonstrated between the maternal BMI categories and the LBW categories for this sample.

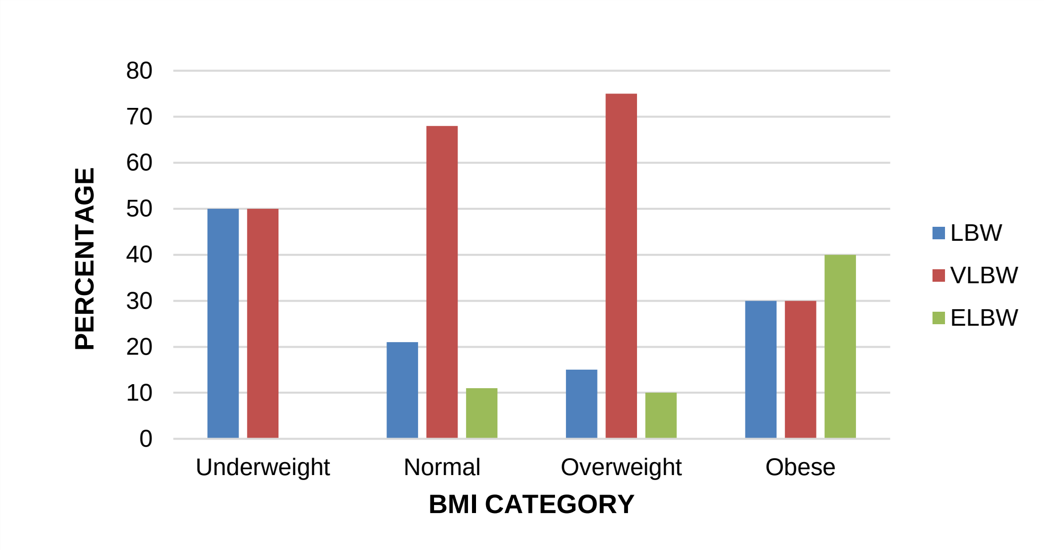

Figure 4.3.2: BW category by BMI category

There was also no statistical significant association between maternal HIV status, hypertension and diabetes, and the various BW categories in this sample. Furthermore, no significant associations could be demonstrated between age groups, BMI categories and social risk behaviour and the various BW categories in this sample. It was interesting to note that 40% of the obese maternal participants had ELBW infants.

Of the total number of obese women (n=10) in the sample size, 60% (n=6) had hypertension. Of the obese women who gave birth to ELBW infants (n=4), 75% (n=3) had hypertension. Of the obese women who gave birth to VLBW infants (n=6), 50% (n=3) had hypertension. To summarise, most obese women (n=10) with hypertension (n=6), gave birth to VLBW infants (n=3) and ELBW infants (n=3).

It should, however, be considered that no normal birth weight term infants or LBW infants, usually discharged within two days, were part of this sample and that the lack of associations only mean that the different categories of LBW in this sample could not be associated with the maternal age, clinical history, BMI categories or social risk behaviour.

4.4 GENERAL GROWTH VELOCITY OUTCOMES

This study aimed to describe the effect of maternal supplementation compared with fortification, on growth velocity in hospitalised LBW premature infants receiving supplementation, and or fortification within the proposed studysample.

Growth velocity, as mentioned in chapter three of this dissertation, is an ideal way in which to measure growth outcomes in preterm infants. In this study, growth velocity was monitored to determine the effect that the various supplementation groups had on the growth of LBW preterm infants. Growth velocity was categorised into three as poor (<10g/kg/day), adequate (10-15g/kg/day) and good (>15g/kg/day).

Upon entry into the study, i.e. on the first visit, out of the total infant sample (n=91), the mean weight was 1317.58g (SD=212.42). Table 4.4.1 illustrates the central tendency of weight between the first and last visit. The lowest weight upon the first visit was 870g. The maximum weight entered into the study was 1880g. The mean weight of the "last visit" had a mean of 1565.6g (SD=168.9). The range of weights for the last visit was between 1040g and 2050g. The mean weight increased from 1317.58g (SD=212.42) to 1565.6g (SD=168.9) (Table 4.4.1)

Table 4.4. 1: Central tendency of weight and growth velocity between the first and last visit (n=91)

	Mean	SD	Minimum	Quartile 1	Median	Quartile 3	Maximum
First Visit: Weight (g) (entry to study)	1317.58	212.42	870	1185	1310	1435	1880
Last visit: weight (g) (Exit weight upon discharge)	1565.60	168.90	1040	1480	1530	1640	2050
Last Visit-First Visit growth velocity(g/kg /day) (Exit – entry)	13.52	6.52	-2.52	9.56	13.46	16.66	34.90

Determining the impact of growth velocity between the first and the last visit was used as an indicator of maternal supplementation groups' on weight gain in the infants.

As illustrated in table 4.4.1 above, growth velocity was calculated by considering the first and last visit. In the total sample (n= 91), the mean growth velocity was 13.52 g/kg/day (SD=6.52) between the first and last visit. The minimum growth velocity was -2.52 g/kg/day whilst the maximum growth velocity was 34.9 g/kg/day. When referring to the minimum category above, growth velocity was at a negative as some infants in the sample did not gain weight between the first and last visit. This could be due to various reasons which is be discussed in chapter five of this dissertation. The median growth velocity between the first and the last visit was 13.46 g/kg/day.

Furthermore, figure 4.4.1 shows the trend in growth velocity according to the different growth velocity categories. Of the sample, 41% (n=37) of infants achieved >15 g/kg/day growth velocity classified as good growth velocity. Of the sample 32% of infants (n=29) fell in the growth velocity category of 10-15 g/kg/day which is adequate growth velocity. Unfortunately, poor growth velocity occurred in 27% of the sample (n=25). Poor growth velocity can be due to various possible reasons i.e. medical and nutritional causes, is and will be further discussed in chapter 5 of this dissertation. From figure 4.4.1, it can be concluded that most infants (n=66) thrived and gained weight at a rate to support catch up growth.

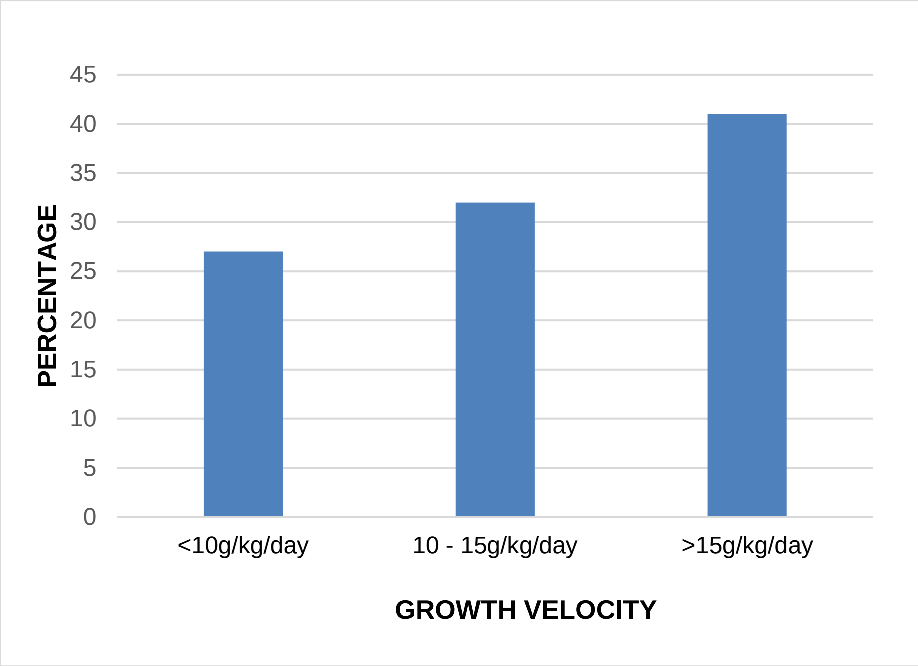

Figure 4.4.1: Growth velocity between first and last visit

The discharge weight criterion at DNH is 1500-1600 g. As seen in figure 4.4.2 below, 53% (n=31) of VLBW infants were discharged within the discharge weight category of >1500-1700 g. Out of the total number of ELBW infants (n=12), 58% (n=7) were discharged at a weight of between 1300 and1500 g.

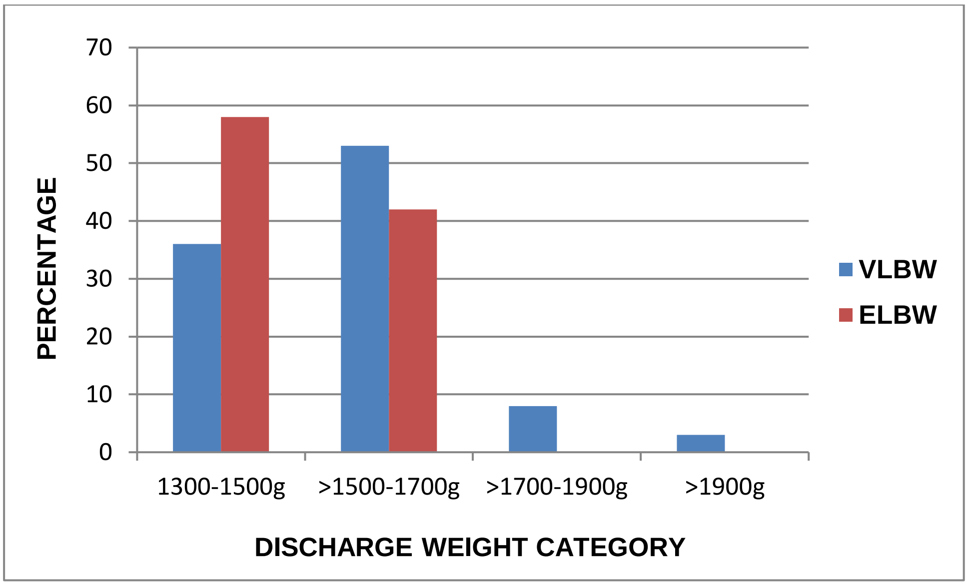

Figure 4.4.2: Discharge weight category by BW category

4.5 THE RELATIONSHIP BETWEEN MATERNAL RISK FACTORS AND PRETERM GROWTH VELOCITY

A one-way analysis of variance (ANOVA) was used to compare the effect of various risk factors on growth velocity indicated.

4.5.1 Maternal smoking

Out of the total number of smoking mothers (n=16), 38% (n=6) received maternal supplementation and BM fortification. The mean growth velocity of this group was 9.8g/kg/day (SD=15.4). Of the total number of smoking mothers (n=16), six percent (n=1) received fortification only. The participant had a mean growth velocity of 15.09 g/kg/day (SD=11.85). Of the total number of smoking mothers (n=16), 56% (n=9) received maternal supplementation only. The mean growth velocity of the infants in this group was 10.92 g/kg/day (SD=7.85). The infant participants in the group that only received fortified BM, had the highest mean growth velocity compared with the other supplementation groups in the study. However, the numbers were too low for further inferential statistics.

Out of the total group of non-smoking mothers (n=72), 63% (n=45) received supplementation only (table 4.5.2). The mean growth velocity of the maternal supplementation only group was 8.52 g/kg/day (SD=10.62). In the non-smoking category, 21% of infants received fortification only (n=15). This group had a mean growth velocity of 12.2 g/kg/day (SD=12.25). Out of the total non-smoking mothers (n=72), 16% (n=12) received maternal supplementation and the infant's BM fortification. This group had a mean growth velocity of only 7.5 g/kg/day (SD=12.17). This was the lowest mean growth velocity out of the rest of the supplementation groups studied in the non-smoking category.

Table 4.5.2:Distribution of growth velocity by maternal smoking and non-smoking

	Smoking				**Non- smoking**			
	n	%	Mean	SD	n	%	Mean	SD
Maternal supplementation and BM fortification	6	38	9.80	15.40	12	16	7.5	12.17
Maternal supplementation only	9	56	10.92	7.85	45	63	8.52	10.62
Fortification only	1	6	15.09	11.85	15	21	12.20	12.25
TOTAL	16	100			72	100		

A higher percentage of mothers in the smoking category (38%) had infants who required an additional form of supplementation to achieve adequate growth velocity versus the non-smoking category mothers (16%).

Despite the differences in mean growth velocities, no statistical significant difference was demonstrated between maternal smoking and growth velocity outcomes.

4.5.2 Maternal nutritional status

Of the total sample (n=88), 61% (n=54) of mothers had a normal BMI (table 4.5.3). The mean growth velocity of infants whose mothers had a normal BMI, was 12.75 g/kg/day (SD=5.67). Of the total maternal sample (n=88), 23% (n=20) were overweight. The mean growth velocity for infants with overweight mothers, was 16.2 g/kg/day (SD=8.71). Of the maternal sample, 11% (n=10) were obese. The obese category had infants with a mean growth velocity of 11.07 g/kg/day (SD=4.44). This was the lowest mean for growth velocity amongst the various BMI categories.

Table 4.5.3 : Distribution of infants' growth velocity by maternal BMI categories

BMI	n	%	Mean	SD
Underweight	4	4	18.81	4.57
Normal	54	61	12.75	5.67
Overweight	20	23	16.24	8.71
Obese	10	11	11.07	4.44
TOTAL	**88**	**100**		

Lastly, only 4% (n=4) of mothers in the study sample were underweight. The underweight mothers had infants with a mean growth velocity of 18.81 g/kg/day (SD=4.57). This is the highest mean growth velocity amongst all BMI categories. Table 4.5.5 illustrates the mean infant growth velocities amongst the maternal risk factors. Despite the difference in mean growth velocities between the groups as illustrated in table 4.5.4, no statistical significant differences were observed between growth velocity and BMI categories.

Table 4.5.4: Mean infant growth velocity according to maternal risk factors and supplementation group using ANOVA

RISK FACTOR		**GROWTH VELOCITY (g/kg/d)**						
		n	**%**	**Mean**	**SD**	**F value**	**DF**	**P**
1. DISEASE								
1.1 HIV	Positive	31	35	11.23	6.01	2.47	1;1	.120
	Negative	57	65	14.93	6.51			
1.2 Hypertension	Yes	30	34	13.53	7.4	0.59	2;2	.558
2. NUTRITIONAL								
2.1 BMI	Underweight	4	5	18.81	4.57	2.05	3;1	.114
	Normal	54	61	12.75	5.67			
	Overweight	20	23	16.24	8.71			
	Obese	10	11	11.07	4.44			
3. SOCIAL								
3.1 Smoking	Yes	16	18	16.14	4.64	3.54	1;3	.064
	No	72	82	13.07	6.81			
4. Supplementation								
4.1 Maternal Supplementation		54	61	12.26	5.41	**4.88**	**2;75**	**.01***
4.2 Fortification of breast milk		16	18	19.75	6.45			
4.3 Maternal Supplementation & Fortification of breast milk		18	20	12.29	6.97			

***** p<0.05 statistically significant

4.6 GROWTH VELOCITY IN THE VARIOUS SUPPLEMENTATION GROUPS

Findings indicate that the different supplementation approaches resulted in statistically significant differences in the supplementation groups in terms of the mean growth velocity of infants (Table 4.5.4).

As previously explained, the supplementation approaches in the study included a group receiving maternal supplementation in the form of an oral drink, a group receiving maternal supplementation and BM fortification, and the third group received BM fortification alone.

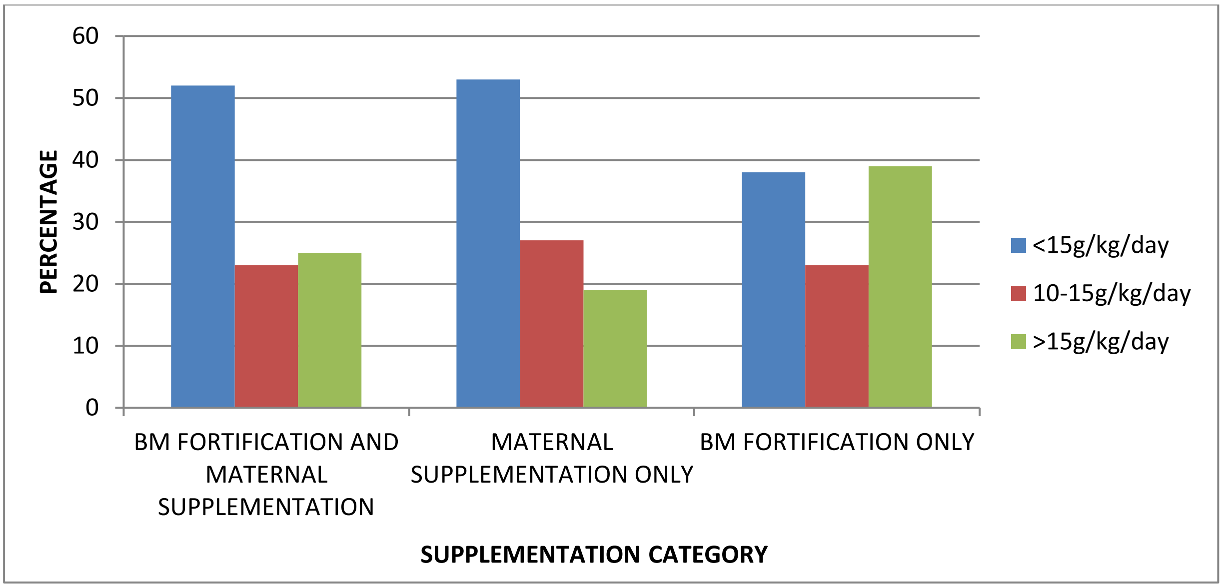

Figure 4.6.1: Supplementation category by growth velocity category

The supplementation categories by BW categories is illustrated in figure 4.6.1. The maternal supplementation only (n=54) category was the group who scored the poorest growth velocity. The BM fortification only group (n=16) was the group who had the best growth velocity throughout all of the supplementation groups.

4.6.1 Maternal supplementation

Of the total maternal sample (n=88), 61% (n=54) received maternal supplementation. Distribution of growth velocity by supplementation category is illustrated in figure 4.6.2. The maternal supplementation group had a mean growth velocity of 12.26 g/kg/day (SD=5.41). This is the lowest mean growth velocity between the supplementation groups studied.

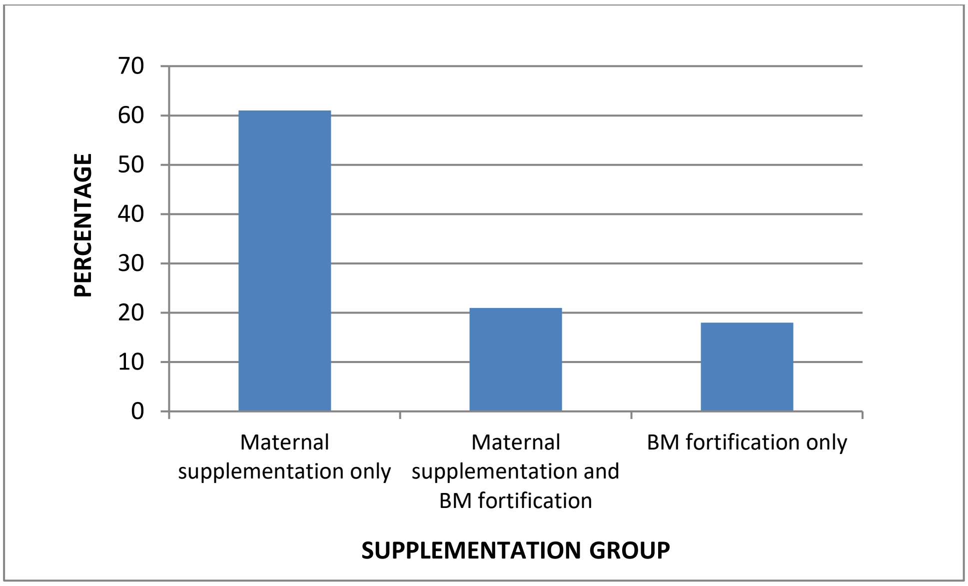

Figure 4.6.2: Distribution of growth velocity by supplementation category

4.6.2 BM fortification

Of the total infants in the study sample (n=91), 18% (n= 16) received fortification (Figure 4.6.1). The fortification group had a mean of 19.75 g/kg/day (SD=6.45). As seen in figure 4.6.3, the fortification group had the highest mean growth velocity in the study with the highest mean confidence interval. The BM fortification sample therefore had a greater growth velocity versus the other two supplementation groups studied (figure 4.6.3).

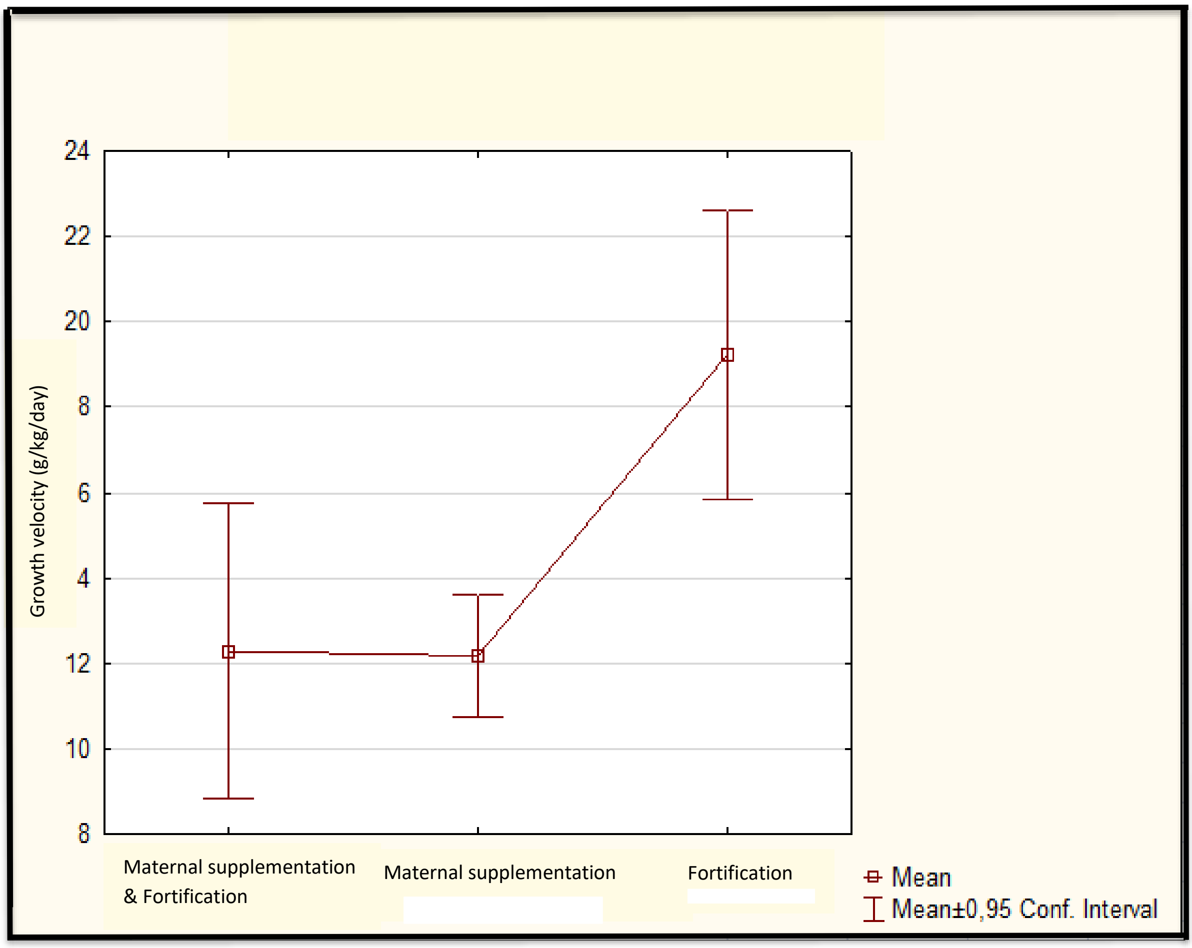

Figure 4.6.3: Mean infant growth velocity according to supplementation group (n=91)

4.6.3 Maternal supplementation and BM fortification

Of the sample, 20% (n=18) of the study sample received both maternal supplementation and BM fortification. This group had a mean growth velocity of 12.29g/kg/day (Figure 4.6.2). This group had the second highest mean growth velocity out of the three supplementation groups studied. When referring to the figure 4.6.3, the maternal supplementation and fortification group was the only group who had extremes with negative growth velocity.

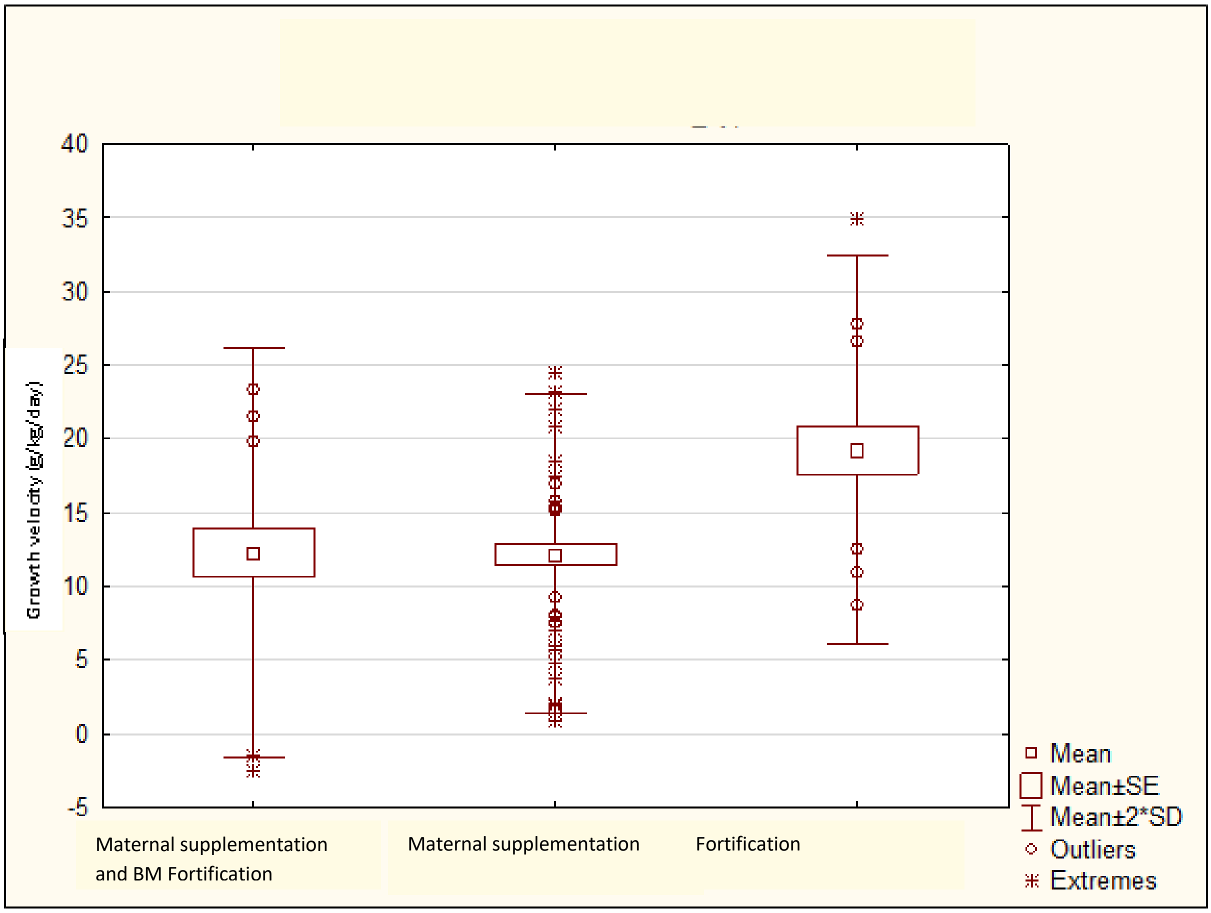

Figure 4.6.4: Box plot presenting growth velocity according to supplementation group (n=91)

No statistical significant differences in mean growth velocity were demonstrated between maternal disease groups, BMI groups and social risk factor groups in the study sample.

Because statistical significance differences was found between the supplementation groups on growth velocity, further investigation needed to occur in order to find explanations to the statistical significance amongst various supplementation groups. Using ANOVA and post hoc tests, growth velocity and length of hospital stay were tested for the various supplementation groups.

4.7 THE EFFECT OF MATERNAL SUPPLEMENTATION ON GROWTH VELOCITY

As mentioned previously and as seen in table 4.5.4, the mean growth velocity of the maternal supplementation only category was 12.26 g/kg/day (SD=5.41).

A post hoc test was done on the supplementation groups to determine differences between the outcomes of the supplementation approaches. This is illustrated in table 4.6.1 below. Comparisons using the Scheffe post hoc criterion for significance indicated that the average growth velocity was significantly lower in the group who received maternal supplementation only (mean=12.26 g/kg/day) than the fortification only group (mean=19.75 g/kg/day). Practical significance using Cohens d test showed a significant difference of large practical importance (d=1.32). This means that a large effect size was demonstrated for the difference between the BM fortification only and supplementation only group.

Table 4.6.1: Post hoc demonstrating comparisons in growth velocity between various supplementation groups

EFFECT		GROWTH VELOCITY				
Supplementation group 1	Supplementation group2	Mean of supplementation group 1	Mean of supplementation group 2	Scheffe p	Cohen's d	p-value
Supplementation & Fortification	Supplementation only	12.29	12.26	1.000	0.01	**0.010***
Supplementation & Fortification	Fortification only	**12.29**	**19.75**	**.001**	**1.11**	
Supplementation	Fortification only	**12.26**	**19.75**	**0.000**	**1.32**	

*p<0.05 statistically significant

4.8 THE EFFECT OF BM FORTIFICATION ON GROWTH VELOCITY

Infants who received BM fortification only (n=16) thrived with a mean of 19.75 g/kg/day (SD=6.5). Figure 4.6.3 clearly indicates the differences in mean growth velocities of the fortification group only versus the other two supplementation groups.

The fortification group (mean=19.75 g/kg/day), had a 7.46 g/kg/day greater growth velocity than the group who received both maternal supplementation and fortification (mean=12.29 g/kg/day). Comparisons using the Scheffe post hoc criterion for significance (table 4.6.1) indicated that the average growth velocity was significantly lower in the group who received maternal supplementation and BM fortification (mean=12.4 g/kg/day), than in the group who received fortification alone (mean=19.75 g/kg/day). Practical significance, using Cohens d test showed a significant difference of practical importance (d=1.11). This means that the fortification alone made a big enough difference on growth velocity and was consistent enough throughout the sample.

4.9 THE EFFECT OF MATERNAL SUPPLEMENTATION AND BM FORTIFICATION ON GROWTH VELOCITY

The supplementation and BM fortification group performed similar, in terms of growth velocity, to the maternal supplementation only group with a mean velocity of 12.29 g/kg/day (SD=6.97).

A post hoc test was done and on the supplementation groups on maternal supplementation and BM fortification group with maternal supplementation only group (table 4.6.1). The maternal supplementation and BM fortification group (mean=12.29 g/kg/day) had a similar mean growth velocity than the maternal supplementation only group (mean=12.26 g/kg/day). This means that the effect of maternal supplementation and BM fortification was not different to maternal supplementation throughout the sample.

As mentioned in chapter three of this dissertation, the maternal supplementation and BM fortification only group formed part of the sample who needed an additional form of supplementation due to poor growth velocity.

4.10 THE RELATIONSHIP BETWEEN LENGTH OF HOSPITAL STAY IN THE VARIOUS SUPPLEMENTATION GROUPS

The possibility that nutrition can cause a decrease in length of hospital stay is a topic often researched.

Within the total sample (n=91) the mean length of hospital stay was 15 days (SD=10.30). Table 4.8.1 describes the distribution of length of hospital stay by supplementation category.

Table 4.8.1: Distribution of length of hospital stay by supplementation category

Supplementation	**n**	**%**	**Mean (days)**	**SD**
Maternal supplementation only	56	62	14	8.99
Maternal supplementation and BM fortification	18	20	24	12.56
BM fortification only	17	19	11	7.02
Total	**91**	**100**		

Within the total sample (n=91) as illustrated in table 4.8.1, 62% (n=56) of infants received maternal supplementation only with a mean length of hospital stay being 14 days (SD=8.99).

Within the total sample size (n=91), 20% (n=18) received maternal supplementation and BM fortification. This group's mean length of hospital stay was 24 days (SD=12.56). Infants in this category receiving maternal supplementation and BM fortification had the longest mean length of hospital stay. Lastly, 19% (n=17) of infants received fortification only. The mean hospital length of stay in this group was 11 days (SD=7.02). This supplementation group had infants with the shorter length of hospital stay compared to the maternal supplementation and fortification group.

A Univariate ANOVA was conducted to compare the effect that the supplementation groups had on the length of hospital stay. This comparison is better illustrated in table 4.8.2 below.

Table 4.8.2: Univariate ANOVA results: lengths of stay per supplementation group

EFFECT		LENGTH OF HOSPITAL STAY						
Supplementation level 1	Supplementation Level 2	Mean of supplementation 1	Mean of supplementation 2	Scheffe	Cohens d	F value	D.F	P Value
Supplementation & Fortification	Supplementation	**23.61**	**13.88**	**.001**	**.98**	**9.06**	**2;88**	**<.0005***
Supplementation & Fortification	Fortification	**23.61**	**11.29**	**.001**	**1.20**			
Supplementation	Fortification	13.88	11.29	.619	0.30			

*p <0.05 statistically significant

The highest mean within all supplementation groups for length of stay was in the maternal supplementation and fortification group. This result is expected. As mentioned above, originally, infants who received both maternal supplementation and fortification did not thrive on one form of supplementation. This meant that the infant needed an additional supplementation strategy in order to thrive adequately enough with a growth velocity of 10-15 g/kg/day and it took longer to implement. The lowest mean in terms of hospital stay, was the BM fortification only group. Here, results make sense as the fortification only group had the highest mean growth velocity meaning that infants reached the discharge weight of 1500 g at a faster pace than the other supplementation groups. This means that the BM fortification only group had the shortest length of hospital stay compared with the other supplementation groups studied (F= (2, 88) =9.06, p <0.0005).

Post hoc comparisons using the Tukey HSD test indicated that the mean length of hospital stay for the maternal supplementation and fortification group (mean=23.61 days; SD=12.56) was significantly different from the maternal supplementation only group (mean=13.88 days; SD=8.99). Another post hoc comparison indicated that the mean length of hospital stay for the maternal supplementation and fortification group (mean=23.61 days; SD=12.56) was significantly more than the fortification only group (mean=11.29 days; SD= 7.02). Furthermore, the Cohen's d effect size value (d=1.2) suggests a high practical significance. No statistically significant difference could be demonstrated between the supplementation only and fortification only groups.

This meant a longer hospital stay for the maternal supplementation and fortification group, because the infant would reach discharge weight of 1600g, at a slower rate than the maternal supplementation only and fortification only group. In summary, the fortification only group had the shortest length of hospital stay compared with the other supplementation groups studied, but it was not statistical significant better than the maternal supplementation group.

4.11 CONCLUSION

This study aimed to describe the effect of maternal supplementation and or fortification on growth velocity and LOS in hospitalised LBW premature infants within the NMB health district.

The prevalence of the various LBW infants was as follows: 65% of infants were VLBW (n=59), 22% were LBW (n=20) and 13% of infants were ELBW (n=12).

Within various supplementation groups studied, 61% (n=54) of infants received maternal supplementation only, 20% (n=18) receive maternal supplementation and fortification and 18% (n=16) of infants received fortification only. Within these supplementation groups, the fortification only group had the highest growth velocity in the study with a mean of 19.75 g/kg/day (SD=6.45). The maternal supplementation only group had the lowest mean growth velocity of 12.26g/kg/day (SD= 5.41).

With use of the above supplementations, 41% of infants had good growth velocity. Of the sample, 32% of infants gained adequately (n=29), while 27% of sample thrived poorly (n=25) and did not attain 10g/kg/day. Therefore, bearing the above in mind, 73% of infants in the study samplethrived in this study and 27% of infants did not grow according to growth standards.

Using ANOVA to determine the relationship between maternal risk factors and growth velocity revealed no statistical significant differences in mean growth velocity between maternal disease groups, BMI groups and social risk factor groups in the study sample. However, a statistically significant difference was found between the growth velocities of the various supplementation groups with a p value of 0.01.

Amongst all three supplementation levels, most infants thrived according to expectations.

By using ANOVA and calculating post-hoc, statistical significance was found between various supplementation groups. A strong relationship was found between growth velocity and BM fortification. The Cohens effect size value (d=1.1) suggests a high practical significance. The BM fortification group had the greatest growth velocity compared with the other supplementation groups tested.

A clear link between nutrition, growth velocity and length of hospital stay exists. ANOVA and a post hoc test was used in order to determine the relationship between the length of hospital stay with the various supplementation groups. Results show that a statistical significance is evident in the length of stay with the various supplementation groups (p=<0.005). More specifically, the maternal supplementation and fortification group showed a longer length of hospital stay and the Cohen's d effect size value (d=1.2) suggest a high practical significance. The fortification only group had the shortest length of hospital stay compared with the other supplementation groups tested but was not significantly shorter than the supplementation only group.

In conclusion, the BM fortification only group faired the best in terms of growth velocity and length of hospital stay compared with the maternal supplementation only group and maternal supplementation and BM fortification group. Discussions regarding results of this chapter will be presented in chapter five of this dissertation.

CHAPTER 5

DISCUSSION

Preterm infants are a population well known for its vulnerable nature. Worldwide, preterm birth is a major cause of death and an even greater cause of long-term loss of human potential amongst its survivors (Blencowe et al., 2013). Because preterm infants' immature organs are poorly suited to the extra-uterine environment, their morbidity risk increases. Due to their organ immaturity, preterm infants are at an increased risk to excessive intestinal inflammation. As mentioned in chapter two of this dissertation, excessive intestinal inflammation in the preterm infant causes a medical condition better known as NEC. In order to prevent NEC, BM comes highly recommended (Gregory et al., 2016). Sound nutritional management in preterm infants thus plays a vital role in survival. This study will be useful in order to inform on evidence based nutritional management of hospitalised preterm infants.

As outlined in the problem setting, current nutritional management of preterm infants recommends the preferred use of BM. For infants who do not gain adequate weight, the addition of BM fortification is recommended. The WHO also recommends that BM fortification be seen as medically indicated in order for survival of the preterm infant (WHO, 2016). The effect of BM fortification among both HIV-negative and HIV-infected mothers, especially in relation to LBW infants, is poorly researched.

Ballard & Morrow (2013) and Lauritzen & Carlson (2011) both acknowledge, thus far, that fat is the only macronutrient with the ability to be altered in BM through the maternal diet. Furthermore, Lauritzen & Carlson (2011) concluded that omega three supplementation is effective for mothers who consume a low total fat intake. According to WHO (2011), food insecurity has become a global crisis. Food insecurity precedes inadequate dietary intake and therefore leads to poor quality of fat intake. Poor quality of fats refers to a lack of essential fatty acid intake (Siri-Tarino et al., 2010). Details regarding specific dietary fats were explained in chapter two. As part of the nutritional protocol at DNH, mothers receive maternal supplementatation due to food insecurity and poor quality of fat intake. This is standard practice at DNH.

In this chapter, results of the study are discussed in relation to current literature. This chapter presents the growth velocity of hospitalised LBW premature infants receiving

BM fortification and or maternal supplementation in hospitalised preterm infants at Dora Nginza hospital. Similarities and differences between the results from this study and other studies are discussed. Finally, by considering chapter four and the discussions in this chapter, recommendations will be developed for the Eastern Cape Department of Health for the possible implementation of optimal preterm nutritional management.

5.1 RELATIONSHIP BETWEEN MATERNAL RISK FACTORS AND LBW

Prematurity is one reason for an infant being born with LBW. In developing countries, LBW is seen as an indicator for perinatal mortality and morbidity. The weight of an infant is a reflection of maternal health and nutritional status (Khan, Nasrulla & Jaleel, 2016).

5.1.1 Maternal age

Maternal age is associated with preterm birth. More specifically, preterm birth is associated with younger and older mothers (CDC, 2016). An association also exists between maternal age and LBW; more specifically, for younger and older mothers (Restrepo-Mendez et al., 2014). Restrepo-Mendez et al (2014) examined the prevalence of LBW and preterm birth in four cohorts. The study examined areas of high and middle-income countries by considering maternal age as a risk factor to preterm birth in this sample. Due to the fact that the principle researcher used purposive sampling, a large number of LBW infant mother pairs who were discharged within two days, were not elligible for the study. Sample properties will therefore be described but associations need to be interpreted with caution.

At Dora Nginza hospital, 36% of mothers in the sample fell under the at-risk age category mentioned in chapter four. Throughout all age categories in the sample, majority of mothers gave birth to VLBW infants, whereas ELBW infants were born to mothers in the age category of 20-35 years old. Mentioned in chapter four, no association was found between maternal age and BW.

A mother's health, with specific reference to the mother's social and behavioural circumstances during and before pregnancy, has the potential to affect the health of her child. Dennis and Melbourne (2013), researched how LBW varies by ethnicity and maternal age. The results of the study suggested that maternal age is seen as a complex product of socio-economic disadvantage and current social and behavioural factors. Furthermore, the results concluded that LBW risk is not individually dependant upon ethnicity or maternal age (Dennis & Melbourne, 2013).

At DNH majority of mothers who fell under the normal age category of 20-35 years old gave birth to ELBW infants. This trend can be linked to Dennis and Melbourne (2013) and contradicts Restrepo-Mendez et al (2014) literature. The population at DNH suffer from poor financial and social circumstances and, therefore, follows the trend that LBW risk is not individually dependant upon maternal age but rather that social and behavioural factors could also be part of the reason for LBW risk.

5.1.2 Maternal nutritional status

As mentioned in chapter two of this dissertation, guidelines recommend that women conceive at a normal weight in order to reach ideal maternal and neonatal outcomes (Kominiarek & Rajan, 2016).

BMI was divided into four categories (cf. chapter 4), anything above or below normal BMI was a risk factor to LBW. The majority of mothers at DNH who participated in the study were of a normal weight (61%) whilst the minority of mothers fell under the at-risk categories of underweight, overweight and obese (39%). Most of the mothers who were overweight, gave birth to VLBW infants, and half of the underweight mothers gave birth to VLBW infants. This links in well with literature by Dennis and Melbourne (2013), where behavioural and social circumstances are seen as a contributing factor to LBW incidence.

Gunderson (2010) explains the term “postpartum weight retention” as the average weight change from preconception to the first year postpartum. The article futher explains that post partum weight fluctuates in women for as long as one-year post partum (Gunderson, 2010). This means that in order to consider accurate nutritional status of the mother, maternal weight should be recorded only once 12 months postpartum has occurred. In the population at DNH, weight before pregnancy and after birth were not recorded and preterm infants were not as old as 12months.

Bearing the literature in mind, normal BMI postpartum could be an over estimation of actual pre-pregnancy BMI at DNH. Simplified, this means that the data in this study is an inaccurate reflection of the actual nutritional status of the mother as post partum weight retension was not taken into consideration. The mean BMI of this study fell under the normal BMI category (24kg/m^2). The concept of over-estimation of actual pre-pregnancy BMI at DNH simplifies the reason for the high percentage of false “normal BMI” category mothers giving birth to mostly VLBW infants. Gunderson (2010) expresses the importance of determining BMI at one year postpartum.

Because maternal nutritional status is strongly associated with LBW incidence, studies found that poor nutritional status had a direct effect on LBW oucomes (Verma & Shrivastav, 2016; Mishra, 2014; Ipadeola et al, 2013). This literature ties in with the trend of maternal nutritional status at DNH and BW incidence. Half of the ELBW infants in this study were born to “normal BMI” mothers and roughly three quarters of VLBW and LBW infants were born to “normal BMI” mothers. This trend highlights the degree of poor nutritional status with poor BW outcomes at DNH, given the documented over-estimation of BMI status might have occured in this study sample. It should also be taken into consideration that poor maternal nutrition is not atttributed to weight or BMI alone, and therefore does not only apply to underweight mothers; overweight and obese mothers can also exhibit poor nutrition (Kimani-Murage, 2013).

Interestingly enough, a trend was found between various BMI categories and BW at DNH. As maternal BMI increased, so the BW decreased. Similarly, obese women had the highest percentage of ELBW infants born throughout all BMI categories studied. This ties in well with existing literature stating that the higher the maternal BMI, the increased the risk of neonatal complications including LBW.

In a Swedish study, maternal overweight and obesity during pregnancy were associated with an increase risk of preterm delivery especially extremely preterm delivery (Cnattingius, 2014). Within the South African context, a similar concept can be concluded. Research done on obesity and its outcomes amongst pregnant South African women concluded that the prevalence of obesity in pregnancy was high and associated with an increase in complications such as preterm birth (Basu, Jeketera & Basu, 2010). This literature is similar to the population studied at DNH and implies that the link between obesity, and the increased risk of birth complications, plus the double burden of disease experienced at DNH, is the reason why the majority of obese women gave birth to ELBW infants. However, despite this trend, no associations could be made between maternal BMI and LBW categories. A possible reason for the missing association could be because maternal BMI is not the only independent cause for LBW risk. Furthermore, maternal social and behavioural circumstances are, as mentioned by Dennis and Melbourne (2013), a complex cause of LBW incidence. This is true for the population at DNH (Dennis & Melbourne, 2013).

At DNH antenatal clinics, overweight and obesity are ignored in terms of LBW risk, but this associated disease means that dietitians should pay special attention to these mothers, especially prior to pregnancy.

Mid upper arm circumference is strongly correlated to BMI during pregnancy. In low resource settings, mid upper arm circumference is a reliable measurement used as a substitute to BMI as an assessment for nutritional status (Fakier, Petro & Fawkus, 2017). Close monitoring of weight by using mid-upper arm circumference should occur routinely in order to decrease the risk to preterm delivery. In this way, by using MUAC, overweight and underweight including exponential weight gain and weight loss during pregnancy can be screened and monitored. In this way, maternal nutritional status will be scaled up and any mother needing nutritional intervention will be referred to a dietitian for further monitoring and councilling.

5.1.3 Hypertension and HIV as risk factors for LBW

Maternal hypertension and HIV infection is generally associated with LBW outcomes (Dadhwal et al. 2017; Rizvi, Saini & Gupta, 2015).

More than half of the total number of ELBW infants in the sample was born to hypertensive mothers. Furthermore, most HIV infected mothers in the study sample gave birth to ELBW infants. Given the incidence of ELBW infants and the maternal risk factors, HIV and hypertension seem to have a positive outcome on LBW in this study. This trend is in line with current literature (above) stating that mothers with HIV and hypertension tend to give birth to LBW infants. The HIV and LBW trend is of specifc concern because, according to Stats SA (2017), and as mentioned in chapter two, there is a high incidence of HIV in SA. If the trend of HIV infection continuous to increase in SA, then the incidence of LBW infants will increase, to their detriment, because LBW is associated with an increase in infant morbidity and mortality. Preventative measures are urgently needed.

5.2 GENERAL GROWTH VELOCITY OUTCOMES

Postnatal growth failure is common in preterm infants. During nutritional management, it becomes mandatory that health professionals strive to mimic the growth that occurs in the intrauterine environment, for the preterm infant (Fenton et al., 2013). Growth velocity is the ideal way in which to monitor growth in preterm infants (cf. chapter 3) (Horbar et al., 2015).

Results from this study showed that there was a positive growth velocity trend in the study population at DNH, between the first and the last visit. The mean weight increased from the first visit and the last. The mean growth velocity between the first and the last visit was 13.52 g/kg/day, therefore classifying overall mean growth velocity as average. However, results from this study indicate that the lowest growth velocity between the first and the last visit, resulted in weight loss (expressed as negative growth velocity).

Despite nutritional interventions, postnatal growth failure between hospital stay and discharge remains a significant issue in preterm infant management (Cooke, 2016). Feeding practices remain a challenge in the neonatal unit, specifically the neonatal intensive care unit. Here, feeding becomes an issue as infants are not always stable enough to receive nutrition due to certain medical conditions.

Infants with cardiac morbidities, as an example, are known to thrive poorly. In preterm infants, patent ductus arteriosus is common. Feeding difficulties occur as the preterm infant becomes fatigued easily or has signs of feeding intolerances. This leads to poor growth velocity outcomes. In these circumstances, infants require fluid restriction which can compromise nutrition of the infant. In these circumstances maintaining an adequate growth velocity becomes difficult to manage (Martins et al., 2015; Saenz, Beebe & Triplett, 2009).

Neonatal intensive care units are focused on vital organ development and therefore nutrition is sometimes introduced gradually in the first weeks of life. The reason for the gradual introduction to nutrition is due to the increased risk to feeding intolerance secondary to digestive system and feeding disabilities. Some preterm infants, more specifically ELBW infants, have a longer length of stay in neonatal intensive care units with a greater need for ventilator support, increased fasting rate and therefore a longer period needed to reach adequate nutrient intakes (Cui, 2013). Sick neonates are at an increased risk to growth failure. Illness itself is known to cause changes in cell metabolism causing a shift in nutritional demand. Conditions such as sepsis, lung conditions, intrauterine growth restrictions and NEC are known to alter macronutrient composition (Ramel, Brown & Georgieff, 2014). The situation at DNH ties into literature mentioned above. These results highlight the importance of medical management and the implication it has on nutritional management of preterm infants. The study results showed that a small fraction of infants had a poor growth velocity. Contributing to poor growth velocity outcomes, are the unfortunate implications of medical management at DNH. Medical management in preterm infants is known to limit the infant's ability to reach full nutritional requirements (due to medication administered as an example) and limit the capacity to develop towards oral feeding (Park, Knafl, Thoyre & Brandon, 2015). This impairs the growth of the preterm infant, as explained in chapter two, and results in poor growth velocity. The trend at DNH of poor growth velocity can therefore be linked to the medical management described above and not only linked to the supplementation groups studied.

Because preterm infants have higher nutritional requirements as mentioned in chapter two of this dissertation, mothers' BM alone does not always meet the preterm infants' nutritional needs. This means that some preterm infants struggle to thrive initially, unless supplementation is provided (Choi et al., 2016). At DNH, results show that 75% of infants gained weight at a rate to support catch up growth. Results were as expected and according to current literature.

It should be taken into consideration that the overall growth velocity mentioned here does not take the individual nutritional supplementation groups into account. Growth velocity mentioned here, is a general impression of the supplementation used in this study. It can be assumed that based on these results, the nutritional supplementation provided played a role in positive growth velocity, as the majority of infants thrived well enough to support normal growth functioning. However, medical conditions were not monitored.

5.3 THE RELATIONSHIP BETWEEN MATERNAL RISK FACTORS AND PRETERM GROWTH VELOCITY

By considering various maternal risk factors involved, no statistical significant relationship or association was found between maternal risk factors and growth velocity. Certain trends, however, were found between maternal smoking and nutritional status as expected. This will be further elaborated on below.

5.3.1 Maternal smoking

Maternal smoking is known to decrease BM production and alter BM composition (Menella, Yourshaw & Morgan, 2007). Older studies seem to support this research. A study done amongst smoking mothers and its effects on lactation concluded that cigarette smoking has a negative effect on BM volumes (Vio, Salazar & Infante, 1991). In a longitudinal birth cohort study and analysis done by Ong et al (2002), infants of smoking mothers were symmetrically small at birth and showed complete catch up growth over the first twelve months of life compared to infants born to non-smoking mothers. More specifically, existing research suggests that because smoking mothers give birth to smaller infants, their infants have an increased risk for later obesity versus infants born to mothers who do not smoke. Within the same review article, Oken et al (2008) further explains that individuals exposed to prenatal smoking may have greater weight gain from birth to two years of age (Oken, Levitan & Gillman, 2008). This research seems to align with Ong et al (2006) who states that complete catch up growth occurs in infants born to smoking mothers over the first twelve months of life.

More non-smoking mothers received maternal supplementation only, compared to smoking mothers. Despite this difference, infants with mothers who smoke still had a greater mean growth velocity in the maternal supplementation only group, compared to infants with non-smoking mothers. Compared to non-smokers, a higher percentage of smoking mothers thus needed an additional form of supplementation; therefore, receiving BM fortification and maternal supplementation. The trend at DNH can therefore be linked to literature mentioned above. The infants of smoking mothers had greater catch-up growth compared to non-smoking mothers. This meant that the infants of smoking mothers, faired better in terms of growth velocity compared to infants of non-smoking mothers. The greater catch- up growth in these infants could possibly be due to the additional supplementation received. Smoking could therefore have an effect on BM production volumes mentioned in the literature above.

5.3.2 Maternal nutritional status

Maternal nutritional status plays a vital role in lactation. Lactating women may have depleted nutritional stores mainly due to the loss of nutrients through colostrum and through BM. This comes from the nutrient stores of the mother. The conversion of nutrients from food to nutrients in BM is therefore not complete if the mother has poor nutrient stores. For a lactating mother to have a good nutritional status, she needs to increase her nutrient intake (Ares-Segura, Ansótegui & Díaz-Gómez, 2015)

A pattern exists between maternal nutritional status and lactation. Logically, a mother who has a poor nutritional status will automatically have poor maternal nutritional reserves. Literature states that in mothers with poor nutritional status, lactation has a negative impact on maternal weight (Ares-Segura, Ansótegui & Díaz-Gómez, 2015; Ross & Habicht, 1995). This effect, however, was only observed when the breastfeeding infant had adequate growth velocity (Ross & Habicht, 1995).

Mentioned in chapter two of this dissertation, women who are lactating require an additional extra 500 kcal in their diet. Maternal nutritional deficiencies in magnesium, vitamin B6, folate, calcium and zinc have been described during lactation and fat and water-soluble vitamins are secreted into BM. Levels of decreased with maternal nutrient deficiency. Fortunately, these vitamin deficiencies can be rectified by providing maternal supplementation (Kominiarek & Rajan, 2016).

In this study and as mentioned above, the majority of mothers at DNH fell in the normal BMI category. Of special interest were the underweight mothers. Mothers who fell in the underweight category had infants with the highest mean growth velocity. Because mean growth velocity was higher in the BM fortification category, and because half of the infants in the maternal underweight category received BM fortification, this pushed up average mean growth velocity in the underweight BMI category. This means that poor maternal nutritional status was only a partial reflection of the maternal supplementation received by the mother. Additionally, the probable reason for the underweight category having infants with the greatest growth velocity, is because half of infants in the underweight category received BM fortification.In this study, the addition of HMF to expressed BM in the underweight BMI category seemed to have compensated for the potential poorer quality of the BM. Research states that BM fortification favours growth velocity in LBW preterm infants (Morlacchi et al, 2016; Reali et al., 2015).

In this study, infants born to obese mothers had the lowest mean growth velocity. This BMI category received the least amount of BM fortification compared with the other BMI categories studied. Although scoring the lowest mean growth velocity amongst BMI categories, this group's mean growth velocity could be classified as adequate. More than three quarters of mothers in this BMI category received maternal supplementation. The maternal supplementation received in the obesity group, had a sufficient impact on the mean average growth velocity to support catch up growth. The definition of malnutrition states that undernutrition not only relates to underweight, but to obesity as well (Steyn & Mchiza, 2014). Current literature by Ares-Segura, Ansótegui & Díaz-Gómez, 2015 states that poor maternal nutritional status has an effect on BM nutritional composition. By bearing the adequate growth velocity in this group in mind, at DNH, maternal supplementation seemed to have an effect on BM composition much like literature states. This means that poor nutritional status occurred in the obese group and therefore maternal supplementation had an effect on BM nutritional composition and simultaneously affected growth velocity outcomes.

5.3.3 Maternal HIV status

Nutrition plays a vital role in HIV. According to the WHO (2015), infants born to mothers living with HIV exhibit poorer growth than infants born to mothers who are uninfected. HIV infected people are known to have an increase in nutritional requirements.

In this study, the majority of HIV-positive mothers received maternal supplementation. Between the HIV-positive and negative groups, the maternal supplementation and BM fortification group was mostly received by the HIV negative mothers.The HIV negative mothers had infants with a greater mean growth velocity compared to HIV positive mothers. More than half of infants born to HIV negative mothers received BM fortification only. At DNH, this means that for the HIV negative mothers, BM fortification was enough to support adequate growth velocity. This ties in with current literature regarding BM fortifications positive effect on growth velocity as mentioned previously (Morlacchi et al, 2016; Reali et al., 2015).

Most HIV infected mothers at DNH needed maternal supplementation only (without the need for an additional form of supplementation) in order for their infants to thrive adequately compared with HIV-uninfected mothers. HIV-infection during lactation results in additional nutritional requirements and bearing the poor hospital dietary intake in mind, the HIV infected mother needed a nutritional supplement to boost her dietary intake and ultimately possibly altering her BM production. This could account for the reason as to why the majority of HIV-infected mothers receiving maternal supplementation, had a mean adequate growth velocity. This was not, however, a better mean growth velocity compared to the HIV-uninfected mothers whose infants mostly received BM fortification and had a greater mean growth velocity compared to HIV infected infants.

5.4 THE EFFECT OF MATERNAL SUPPLEMENTATION ONLY ON GROWTH VELOCITY

The double burden of malnutrition, coupled with the FBDG number eight (mentioned in the problem statement), play a critical role in maternal nutrition (Vorster, Badham & Venter, 2013). If suboptimal maternal nutritional practices occur, the mothers' BM quality could provide suboptimal nutrition to her infant (Ballard & Morrow, 2013). Therefore, the addition of healthy fats (chapter two) to malnourished lactating mother could have an impact on the growth velocity of her infant.

In this study, results show that average growth velocity in the supplementation only group was associated with a significantly lower growth velocity compared with the fortification only group. In conclusion, BM fortification had a greater effect on growth velocity than the maternal supplementation.

The majority of infants in the maternal supplementation only group thrived adequately to support catch up growth. However, these results were not consistent. To put this into context, it would mean that mothers in this group who received maternal supplementation only required this source of supplementation to increase maternal nutritional status and thus the quality of their BM.

Results in this study show that maternal supplementation could be of great benefit as part of nutritional management of preterm LBW infants. The infants placed in this supplementation category had an adequate mean growth velocity. This form of supplementation could be successful to improve lactation by the addition of MUFAs and PUFAs to the maternal diet. This form of supplementation could therefore play an important role as part of the current nutritional protocol at DNH. In this study, because results showed that the majority of infants had an adequate mean growth velocity, maternal supplementation should be suffient to support growth. As mentioned previously, lactating women have additional nutrient requirements. Because DNH suffers from tremendous cost restraints, the current food budget is not optimal enough to support nutritional needs for an adult. This is due to procurement issues that affect the entire hospital. The tender payements from the food service budget is not always up to date and this causes companies to withhold delivery to the food service unit. This is when the food service unit at DNH are obligated to make meals that are not nutritionally up to standard. The dietetics department, however, is in a position to ensure that maternal supplementation is available to lactating mothers at all times. Because preterm mothers stay for longer periods of times at DNH compared with full term mothers, they consume the hospital diet for longer periods of time. This means that the lactating mothers with preterm infants consume an inadequate diet whilst in hospital with their infant. On the other hand, the diet consumed in hospital could be a better form of nutrition for the mother compared to food intake at home. Whether nutrition is better or worse in hospital compared to household food intake, suboptimal maternal nutrition during lactation still persisits during hospitalisation. The addition of maternal supplementation therefore makes a difference in the overall maternal dietary intake, regardless of the mothers BMI status, age category or chronic illness experienced.

5.5 THE EFFECT OF BM FORTIFICATION ONLY ON GROWTH VELOCITY

According to literature, BM fortification is aimed to support postnatal growth at a velocity that is similar to foetal growth (Radmacher & Adamkin, 2017).

For fortification to be administered to patients, preterm infants are required to have reached full maintenance fluid of 150 ml/kg/day. This goes according to the nutritional protocol at DNH and is part of standard practice. Three approaches to fortification are available. DNH uses the standard fortification process, which is the most common approach used. This is the most widely used strategy and is based on the assumption that the BM being fortified, has a protein content of 1.5 g/dL. Preterm infants receiving BM fortification, are required to be on full maintenance fluid of 150 – 180 ml/kg/day. A fixed dosage of fortifier (1g in 25 mls EBM) is added to milk over the entire fortification period (Radmacher & Adamkin, 2017; Di Natale & Di Fabio, 2013). Existing literature regarding preterm infants shows a strong and consistent association between rapid infancy weight gain and an increased subsequent obesity risk (Belfort et al., 2013;Ong & Loos, 2006).

As mentioned before, the BM fortification only group in this study, had the greatest mean growth velocity compared with the rest of supplementation groups studied. From the results, risk factors of all mothers whose infants mostly received BM fortification, showed higher mean growth velocities compared to the remainder two groups in the study. However, although BM fortification resulted in a positive growth velocity of greater than 15 g/kg/day at DNH, it also poses a possible increased risk to obesity for the preterm infant later in life if growth velocity is not monitored closely enough. The results showing good growth velocity in this study are recommended for LBW preterm infants, but the possibility of preterm infants gaining excessive weight, according to literature, is not recommended. This means that at DNH, close growth monitoring needs to occur at ward level, especially when an infant is receiving fortification, in order to monitor periods of excessive growth velocity.

5.6 THE EFFECT OF MATERNAL SUPPLEMENTATION AND BM FORTIFICATION GROUP ON GROWTH VELOCITY

The maternal supplementation and BM fortification groups had similar growth velocity to the maternal supplementation only group. Despite receiving two forms of supplementation, infants in this group did not have a greater mean growth velocity than the fortification only group.

Much like the supplementation only group, the average growth velocity of maternal supplementation and BM fortification group was classified as adequate. This is because, overall, the sample placed in this group was originally suffering from poor growth velocity. This meant that additional supplementation of any kind was needed in order for the preterm infant to reach adequate growth velocity. Originally, the reason for creation of this group, was due to poor growth velocity, and ethical considerations being put into practice in this study, by providing an additional form of supplementation. In keeping with literature (Radmacher & Adamkin, 2017 and Belfort et al., 2013) the BM fortification group thrived exceptionally well. It is postulated that the addition of BM fortification was the cause of this group having a slightly higher mean growth velocity compared to the maternal supplementation only group.

It should be noted that medical conditions could be another reason as to which this group needed an additional form of supplementation to thrive adequately. Medical indications were touched on previously in this chapter and were not monitored as part of this study.

Despite poor initial growth velocity in this group, with the additional supplementation, adequate growth velocity occured, and this group thrived well, despite circumstances. Therefore, at DNH, the indication for an additional form of supplementation when needed to prevent poor growth velocity is warranted to achieve adequate growth velocity and prevent poor growth outcomes in LBW preterm infants.

5.7 THE RELATIONSHIP BETWEEN LENGTHS OF HOSPITAL STAY IN THE VARIOUS SUPPLEMENTATION GROUPS

A statistical significant association was found on the length of hospital stay and the nutritional supplementation group.

The length of hospital stay of preterm infants is of growing concern especially when considering the scarce resources available to health care facilities (Coimbra et al., 2016). The variation in length of hospital stay can be due to various medical treatments received and is generally case specific (Helle et al., 2007).

The maternal supplementation and BM fortification group had the longest mean length of hospital stay. The infants in this group were generally not thriving, thus the initial supplementation choice had to be amended and because of this, they only reached a discharge weight of 1600g. Another reason for the longer length of stay in this group could be because of various case specific medical treatment received. As mentioned before in this chapter, nutrition is not the only indicator that affects preterm infant outcomes, but medical management as well (Helle et al., 2007). It could be argued that infants in this group were generally more ill and needed more individualised medical treatment and therefore were not reaching nutritional goals as fast as the other two supplemental groups studied. In turn, this resulted in the longer length of hospital stay as shown in results. The results of this study also revealed that the fortification only group had the shortest length of hospital stay. This also ties in with the effect that BM fortification had on growth velocity. A higher mean growth velocity meant a faster discharge (Reis et al., 2006) was reached in the BM fortification only group compared to the maternal supplementation only group and maternal supplementation and BM fortification group.

The implications of the results of this study in terms of shortening the length of hospital stay could be of significant advantage. The reason for this is because if we are able to decrease the length of hospital stay by buffering the nutritional protocol at DNH, this will have the power to save costs to DNH and, subsequently, the Eastern Cape Department of Health.

5.8 RECOMMENDATIONS

The following recommendations are based purely on the outcomes of this study.

5.8.1 Recommendations for Department of Health

- Although the WHO recommends the use of BM fortification as medically indicated, because the use of BM fortification adheres to the term exclusive breastfeeding, the health care practitioner should consider the HIV exposed infant (WHO, 2011). For example, if the preterm infant has an adequate growth velocity, the health care worker should carefully consider whether the use of BM fortification is necessary. Literature indicates a link between exponential growth velocity in preterm infants with obesity later in life. Accordingly, this study, cautions the use of excessive BM fortification usage. Infants, who are on recommended BM fortification dosages as instructed by the health professional, should have their weigh monitored daily in order to avoid excessive growth velocity outcomes.
- Of importance, is the reality of the double burden of malnutrition that includes both underweight and obesity. Both underweight and obese women, as mentioned before, lack dietary diversity, especially regarding necessary fats in

the diet (MUFA's and PUFA's). These necessary fats are requisite for lactation. Results in this study show that malnutrition affected both underweight mothers and obese women, thus the need to provide an additional source of maternal nutritional intake (maternal supplementation). This caused a positive effect on the growth velocity of the infants in this study in the form of an adequate mean growth velocity. This means that by including maternal supplementation into the diet, the addition of healthy fats mentioned in chapter two of this disseratation, has the possibility to influence the BM composition in a positive light. Therefore, to save hospital costs in the long run, this study recommends that the department of health implement a bigger nutritional budget to all hospitals with a neonatal unit. With this budget, the use of maternal supplementation, as part of standard protocol for all hospitalised lactating women, should be implemented. The researcher further suggests that BM fortification should be given to all LBW preterm infants who have growth velocity of <15 g/kg/day to support growth and development. Known for its history of good growth velocity which is mentioned in literature, and considering the positive results linked to a shorter length of hospital stay, BM fortification has the potential to save costs to the hospital because discharge weight can be reached sooner.

- The implementation of maternal supplementation in the form of a balanced standard oral drink from a reputable company, preferably one found on governmental tender, is a practical way in which to improve growth velocity outcomes in the LBW preterm infant. Simultaneously hospital costs can be decreased, which is required in resource limited settings. By improving the maternal nutritional status of the mother, the department would be able to improve the nutritional status of the infant. More specifically, the recommended nutritional supplementation needs to contain MUFAS and PUFAs to make a difference in BM composition. This is an advantage to the mother, her infant and the hospital. The researcher suggests that by providing maternal nutritional supplementation to lactating mothers, the increased costs of fortification usage will therefore decrease.
- Currently, especially at DNH, preterm infants are not weighed daily. This is due to the shortage of staff and high volumes of preterm patients in the

neonatal unit. The researcher therefore suggests, due to its importance in improving outcomes, the daily weighing of preterm infants.

- Furthermore, the importance of employing adequately trained nursing staff in the neonatal department comes recommended in this study. This is imperative to ensure that daily anthropometrical measurements are optimally fulfilled, unlike the current situation at DNH. DNH has a high influx of preterm infants due to the high LBW incidence in the EC mentioned in chapter one of this dissertation. This means that preterm infants are only weighed twice per week on so called "weigh days". This is deemed to be due to a shortage of nursing staff. By employing adequately trained nursing staff who can work efficiently with neonates, including the ability to perform daily measurements as required, nutritional monitoring could occur more effectually. Daily weighing of LBW preterm infants would immediately identify infants who are not thriving, resulting in prompt scale up nutrition and accordingly optimal dietetic intervention.

5.8.2 Recommendations for dietitians and other health care workers

- As evident from literature mentioned in this study, as well as the results on maternal nutritional status and the effect that pre-pregnancy weight gain has on birth outcomes, the researcher recommends that more emphasis be placed on weight and mid upper arm circumference monitoring of the pregnant woman in antenatal clinics. In this way, the health care worker is better able to identify malnutrition earlier and to refer to a dietitian and thereby possibly improve maternal nutritional status and birth outcomes.
- The researcher recommends that dietitians increase awareness regarding the importance of adequate nutrition during pregnancy by educating health care workers on this topic and by councelling patients through individual and public talks.
- Furthermore, the researcher recommends that the dietitian encourages all health care workers to recommend any underweight, overweight or obese female to be seen by any available dietitian.
- Because maternal nutrition had a positive impact on growth velocity in a positive light in this study, the researcher encourages the dietitian to

implement the use of maternal nutritional supplementation in all lactating women if resources allow.

- Lastly, the importance of daily weighing of infants is very important for the dietitian to monitor infant growth velocity progression. The dietitian should try his or her best to implement daily weighing in the neonatal department as far as possible.

5.8.3 Recommendations for future research

- Limited data regarding the incidence and prevalence of VLBW and ELBW exists in SA. This study suggests that more research is needed to specify the incidence and prevalence of VLBW and ELBW in the EC.
- The high prevalence of obesity and ELBW births need to be further researched and addressed in a South African context.
- The effect that BM fortification has on HIV transmission rates need to be better researched.
- The effect that maternal supplementation has on BM composition needs to be extensively investigated.

5.9 LIMITATIONS

- Limitations in this study include the fact that the macronutrient composition of BM was unable to be analysed in a laboratory. Findings in this study, was based on the effect of various nutritional supplementations on growth velocity outcomes. A more accurate way to indicate the effect that the nutritional management at DNH had on growth velocity outcomes, would be to focus on the macro and micronutrient changes in the BM content. This could be done by analysing the BM content before supplementation was received and after supplementation was consumed by the mother. By analysing BM composition, more specific conclusions and recommendations can be made especially regarding the effect that maternal nutritional status and supplementation had on growth velocity outcomes. Other researchers should do BM analysis in a South African context especially focusing on the maternal dietary intake and the way in which it affects lactation and macronutrient composition from mother to mother.

- Inaccurate reporting from mothers was a limitation to this study. Majority of mothers reported to have diabetes type one. The reason for the overreporting could simply be since diabetes type one was the first option on the questionnaire and secondly, due to the lack of knowledge regarding individualised diagnoses. This skewed data regarding the reporting of maternal disease history and excludes diabetes as part of maternal disease history. Furthermore, a suggestion would be to elaborate on the difference between type one and type two diabetes and to ask the mother the type of medication received to produce correct results.
- Time was a limitation to this study. Data collection was time consuming as preterm infants have a longer length of hospital stay compared to term infants and therefore sample size in this population was compromised. Preterm infants with an extended length of hospital stay, are faced with multiple medical complications. This meant that reaching full maintenance fluid of BM intake was slower and therefore slower progression of weight gain. This meant that a longer length of hospital stay, provided slower weight gain in the long run. This not only compromised the sample size, but the overall weight gain per participant.
- Because this research was based in a governmental hospital, procurement was a big limitation. Originally, the sample size required a total of 90 LBW preterm infants which where to be divided into three groups of 30 infants. Thirty infants were supposed to receive BM fortification only, 30 infants to receive maternal supplementation and BM fortification and the remainder 30 infants to receive maternal supplementation only. The biggest limitation to this study was the fact that the stock of BM fortification was unable to be delivered due to delivery issues and delay in the process of the fortification order by procurement.

  This delayed the delivery of the stock ordered, which delayed the study, because the researcher was waiting for the BM fortification. Ultimately a limited number of infants received fortification only.
- During this study, DNH received a new neonatologist who altered the management in the neonatal unit. An example that affected this study was discharge weight. Due to the changes in discharge weight some infants were

discharged at a weight range of between 1300g to 1500g, whilst others were discharged with a weight range of between 1500-1600g. This reveals inconsistency in data and prevented precise conclusions about discharge weight being made.

- Based on the changes to discharge weight criteria, from 1500g to 1600g, LBW infants who were stable and had already established weight gain were not required to stay in hospital to await weight gain. In other words, LBW infants (infants who are born between >1500g-2500g), were not required to stay in hospital. This led to inconsistency in data and therefore a large proportion of LBW infants were excluded from the total sample.
- Effects of length of hospital stay and growth velocity outcomes were only based on nutritional supplementation groups used in this study. A limitation to this study was that it did not take medical treatment or length of NICU stay into account. Future research needs to focus on medical management and NICU stay as a confounding factor to growth velocity outcomes.
- This research did not analyse the maternal dietary history and income status to make conclusions about poor nutritional intake. Instead, this research compensated by making conclusions from the growth velocity outcomes on maternal nutritional supplementation. To compensate for this and to make conclusions regarding poor maternal nutritional intake at DNH, the study linked existing statistics on poverty and food insecurity in the EC (specifically rural areas) to this sample. Accordingly, future research needs to focus on maternal dietary history and income of the studied population.
- Gestational age was not consistently indicated in every infant's medical file. This limited the researcher regarding conclusions related to gestatonal age and growth velocity progress. Adding to this factor, conclusions regarding the effect that the various supplementation groups had on growth velocity in different types of prematurity, could not be concluded in this study.

5.10 CONCLUSIONS

This study was conducted on the growth velocity of LBW preterm infants receiving BM supplementation and or maternal supplementation at Dora Nginza Hospital, NMB. This study provides baseline data on the growth velocity of LBW preterm infants receiving BM fortification and or maternal supplementation. This study provides evidence for changing current nutritional protocols in the management of preterm infants in the unique South African context. The recommendations proposed in this study will assist dietitians and health care workers in the nutritional management of infants, whilst simultaneously considering maternal nutritional status.

No associations were found between maternal age, clinical and nutritional status and birth outcomes. However, throughout all age cateogories in this study, most mothers gave birth to VLBW infants at DNH. A trend was found between various BMI categories and BW incidence at DNH. As maternal BMI increased in this group, the BW decreased. Similarly, obese women had the highest percentage of ELBW infants born throughout all BMI categories studied. Out of all HIV infected mothers in the study sample, most gave birth to ELBW infants. There was a higher incidence of ELBW infants in mothers who had the maternal risk factors of HIV and hypertension in this study.

Based on mean results in this study, the maternal supplementation only group thrived adequately to support growth (10-15 g/kg/day). However, these results were not consistent, and this group had the lowest mean growth velocity. Mothers in this group who received maternal supplementation only required this source of supplementation to increase maternal nutritional status. This may be linked to the poor maternal dietary diversity, the poor nutritional status and the double burden of malnutrition experienced at DNH and within the EC. this study recommends that maternal supplementation be implemented as part of standard practice to all lactating mothers.

The BM fortification only group thrived the best with the best mean growth velocity in this study of >15 g/kg/day. BM fortification is thus recommended in this study as part of the standard nutrition procotol at DNH to all LBW preterm infants who are not thriving at 15 g/kg/day. Caution should occur in growth monitoring of these infants to prevent increasing the risk to overweight and obesity later in the preterm infant’s life. Therefore, strict daily monitoring is recommended by the researcher.

The maternal supplementation and BM fortification group had similar growth velocity results to the maternal supplementation only group. However, this group fared slightly better in terms of growth velocity compared with the supplementation only group. Reasons for this group not doing as well as the BM fortification group, could be since this group contained infants who were originally not thriving well enough. Possible additional indicators, such as medical treatment, could also be a reason this group had poor growth velocity, initially.

Overall, the growth velocity of preterm LBW infants at DNH was good in all the groups, with a minority of infants having a poor growth velocity. This study proves that it is possible to achieve adequate growth velocity by the implementation of maternal supplementation. However, these results were not consistent enough to conclude that maternal supplementation alone was enough to support adequate growth velocity at DNH. HMF should be available to add to the expressed BM as soon as the growth velocity drops below the target of 15 g/kg/day. Although valuable lessons were learned, the existing protocol at DNH, based on this study, might not be applicable in all communities of SA and would benefit from wider tests.

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Addendum A: Monitoring sheet

Date:

Instructions:

Please do not forget to fill in the date
Please fill in the applicable blocks with √ or ×
Please ensure that all weight is recorded
Please ensure that mothers have enough supplementation and or fortification for the next day.

Participant number	Scale Calibration	Weight(g)	Weight gain (g/kg/d)	Supplementation received?(mother)	How many times received/day	Fortification received?(baby)	How many times given/day

Addendum B: Data collection sheet

Date: Participant Number:

Please circle the applicable answer.

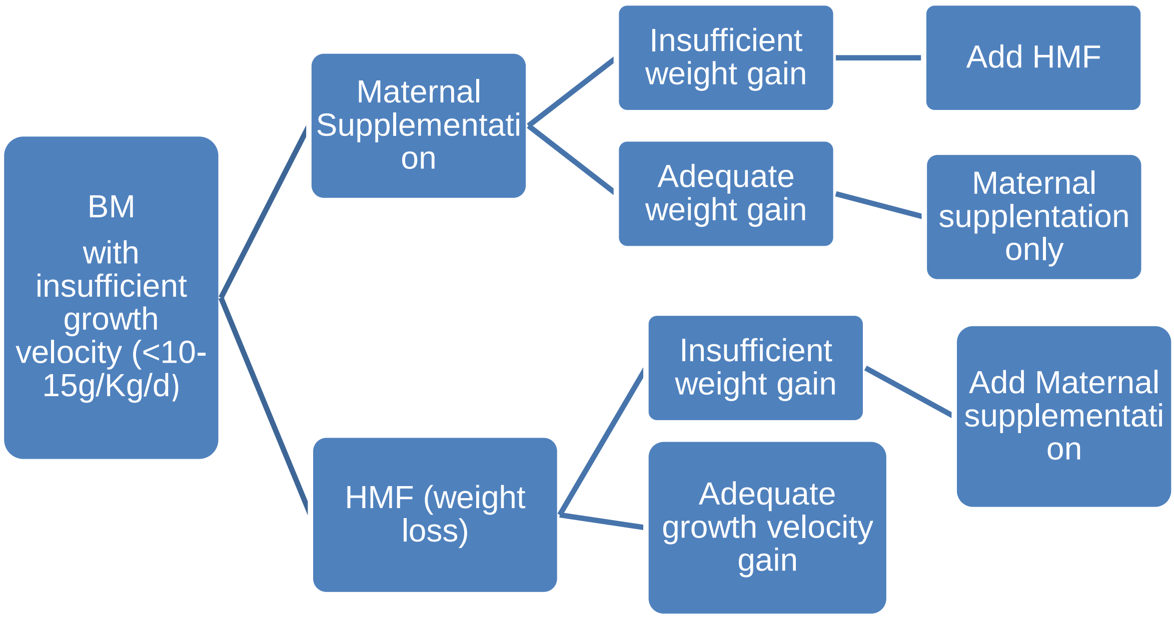
Maternal information:

Ethnicity	White Coloured Black Indian Other
Age	
Number of children (alive) Number of children (deceased)	
First breastfeeding baby?	Yes No
HIV status (in participants file)	Pos Neg Unknown
Chronic diseases	Hypertension
	Diabetes(gestational, type 1 or type 2)
Smoker	Yes No
Alcohol consumption	Yes No
Drugs	Yes No
Income per month (R)	
Weight(kg)	
Height(m)	
BMI (weight/height)^2	

Participant information (found in the participants file):

DOB	
Age	
Gender	Male Female
Birth Weight (g)	
Head circumference at birth (cm)	
Length at birth (cm)	
HIV status	Exposed Negative Unknown
Medical Diagnoses	
EBF	Y N (if no state brief reason)

Addendum C: Supplementation clusters



Addendum D: Consent from Research Ethics Comitee

Nelson Mandela Metropolitan University

for tomorrow

• PO Box 77000 • Nelson Mandela Metropolitan University
• Port Elizabeth • 6031 • South Africa • www.nmmu.ac.za

Chairperson: Research Ethics Committee (Human)
Tel: +27 (0)41 504-2235

Ref: [H16-HEA-DIET-002/Approval]

Contact person: Mrs U Spies

9 July 2016

Dr L Steenkamp
Faculty: Health Sciences
South Campus

Dear Dr Steenkamp

WEIGHT GAIN IN HOSPITALIZED LOW BIRTH WEIGHT (LBW) PREMATURE INFANTS RECEIVING BREAST MILK OR BREAST MILK WITH HUMAN MILK FORTIFIER IN THE NELSON MANDELA BAY HEALTH DISTRICT

PRP: Dr L Steenkamp
PI: Ms R Wicomb

Your above-entitled application served at Research Ethics Committee (Human) for approval.

The ethics clearance reference number is **H16-HEA-DIET-002** and is valid for three years. Please inform the REC-H, via your faculty representative, if any changes (particularly in the methodology) occur during this time. An annual affirmation to the effect that the protocols in use are still those for which approval was granted, will be required from you. You will be reminded timeously of this responsibility, and will receive the necessary documentation well in advance of any deadline.

We wish you well with the project. Please inform your co-investigators of the outcome, and convey our best wishes.

Yours sincerely

CBCilliers

Prof C Cilliers
Chairperson: Research Ethics Committee (Human)

cc: Department of Research Capacity Development
Faculty Officer: Health Sciences

Addendum E: Permission from the Department of Health

Eastern Cape Department of Health

Enquiries:	Madoda Xokwe	Tel No:	040 608 0830
Date:	05 August 2016	Fax No:	043 642 1409
e-mail address:	madoda.xokwe@echealth.gov.za		

Dear Ms. R. Wicomb

Re: Weight Gain In Hospitalized Low Birth Weight (Lbw) Premature Infants Receiving Breast Milk or Breast Milk with Human Milk Fortifier in the Nelson Mandela Bay Health District (EC_2016RP27_564)

The Department of Health would like to inform you that your application for conducting a research on the abovementioned topic has been approved based on the following conditions:

1. During your study, you will follow the submitted protocol with ethical approval and can only deviate from it after having a written approval from the Department of Health in writing.
2. You are advised to ensure, observe and respect the rights and culture of your research participants and maintain confidentiality of their identities and shall remove or not collect any information which can be used to link the participants.
3. The Department of Health expects you to provide a progress on your study every 3 months (from date you received this letter) in writing.
4. At the end of your study, you will be expected to send a full written report with your findings and implementable recommendations to the Epidemiological Research & Surveillance Management. You may be invited to the department to come and present your research findings with your implementable recommendations.
5. Your results on the Eastern Cape will not be presented any where unless you have shared them with the Department of Health as indicated above.

Your compliance in this regard will be highly appreciated.

SECRETARIAT: EASTERN CAPE HEALTH RESEARCH COMMITTEE

Addendum F: Permission from Dora Nginza Hospital

Province of the
EASTERN CAPE
HEALTH

Office of the Senior Manager: Medical Services • 1st Floor • Dora Nginza Hospital • Spondo Street • Zwide • Port Elizabeth • Eastern Cape
Private Bag X11951 • Algoa Park • Port Elizabeth • 6005 • REPUBLIC OF SOUTH AFRICA
Tel: +27 (0)41 406 4201 • Cell: +27 (0)82 956 6709 • Fax: +27 (0)86 590 8759
Email: Jaline.Kotze@ECHEALTH.GOV.ZA or jaline.kotze@gmail.com • Website: www.echealth.gov.za

24 October 2017

Ms R Wicomb

RE: REQUEST TO CONDUCT RESEARCH

Dear Ms Wicomb

This letter serves as confirmation that management is aware of your research conducted during 2016 – 2017 at Dora Nginza Hospital and has no objection to this research under the following conditions:

1. Adherence to the conditions as set out in the ethical approval by NMMU.
2. Adherence to the conditions as set out in the approval from the ECDOH.

I wish you all the success with your research.
Regards,

Dr Jaline Kotze
Senior Manager: Medical Services
Dora Nginza Hospital

Together, moving the health system forward

Fraud prevention line: 0800 701 701
24 hour Call Centre: 0800 032 364
Website: www.ecdoh.gov.za

Addendum G: Written Consent Form

Nelson Mandela Metropolitan University

for tomorrow

Dear Mother

The Dietetics department at Nelson Mandela Metropolitan University (NMMU) is conducting research at the premature unit of Dora Nginza Hospital, Port Elizabeth, Eastern Cape. This research aims to observe the effect that maternal supplementation and or breast milk fortification has on weight gain in low birth weight (<2500g) premature infants in the Eastern Cape**.** This will be observed by monitoring the weight of the premature infant.

Please note that participation in this research is voluntary. Maternal nutritional status is also important as this could also directly or indirectly contribute towards the infants weight gain. As part of this research, it is therefore required that the mothers weight and length be taken in order to calculate Body Mass Index (BMI). If you wish to allow you and your baby to participate in the study, you will be asked some basic questions on your social background. The research also requires extracting information from your baby's hospital file (HIV status, anthropometrical measurements and medical diagnoses). Your baby will be weighed thrice per week by a trained health worker employed by Dora Nginza as part of normal growth monitoring. You as a mother might be given a standard balanced nutritional supplement to drink in order to observe the effect it has on your baby's weight gain and or breast milk fortification to add to your expressed breast milk. This will in no way harm you or your baby.

Participation in the study is completely anonymous and it is your right to withdraw from the study at any point in time. Please note that this study could be used as part of a larger study in the future and therefore we request permission to re-use the information and data gathered for future purposes. Your confidentiality and anonymity will be maintained throughout the data collection, analysis and in any report or publication of the results of the research. The results of the research will be presented to the Department of Health and Dora Nginza hospital to improve the nutritional management of premature units in the Eastern Cape.

All questions, uncertainties or further information is welcome.

Please email or contant Ra-eesa Wicomb RD(SA) at 0828994644 or email Liana.Steenkamp@nmmu.ac.za

Thank you

R.Wicomb

I have read and understood the information in this document, and I provide voluntary consent to participate in the research project

Name	**Signature**	**Date**
Witness Name	**Witness signature**	**Date**