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A Review of Nutritional Recommendations for Pregnant Women Living with HIV

Prepared for the Saskatchewan Prevention Institute

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Table of Contents

Executive Summary

Proper nutrition is important throughout the lifespan but particularly so when a woman is pregnant. During this time, the metabolism of nutrients is affected and a woman must be able to provide sufficient energy for herself and for her baby. In addition, individuals with HIV are susceptible to reduced nutritional status as a result of symptoms of the infection and side effects of antiretroviral medications. As such, pregnant women with HIV face unique challenges of ensuring proper nutritional intake. Women of childbearing age are a demographic that is particularly affected by HIV. The purpose of the current review is to present what research and recommendations currently exist concerning nutrition for pregnant women living with HIV.

The increased energy needs and nutrient deficiencies resulting from both pregnancy and HIV increase demands for both macronutrients and micronutrients. Some nutrients have been found to benefit either the mother or the fetus or both. At times, there may also be detrimental effects.

Vitamin A supplementation during pregnancy was found to reduce the risk of preterm delivery and increase birth weight among women living with HIV. Nonetheless, some researchers remain cautious with the use of vitamin A because of inconsistent evidence around its effectiveness. Insufficient levels of iron and folate can cause anemia, which has been linked to low birth weight, preterm delivery, and increased perinatal mortality. However, iron supplements should be used with caution and taken in the same dosages as that of women without HIV as too much iron can also be harmful. Vitamin D has been potentially linked to preventing adverse pregnancy outcomes, mother-to-child transmission (MTCT) of HIV, and child mortality; however, there are currently no official recommendations for its use. Adequate zinc levels can assist immune function, but research has shown that many HIV-positive patients have deficient levels of zinc, leading to faster HIV disease progression and an increased risk of death. Zinc supplementation seems to be beneficial, but additional research is required to assess the safety of zinc as a nutrient supplement for women infected with HIV. Overall, tailoring nutrient supplements to individuals' specific needs would be difficult and, therefore, researchers have investigated the advantages of multivitamins. At this time, it is suggested that pregnant women living with HIV who do not obtain sufficient nutrients in their diets should take multivitamin supplements**.**

Eating patterns contribute to a healthy pregnancy. Some of the symptoms related to HIV and the use of antiretroviral therapies (ARTs) may result in nutritional consequences such as anorexia, nausea, vomiting, diarrhea, and chewing and swallowing difficulties. Proper dietary management can be an effective way to counteract nutritionally aversive symptoms. Further, monitoring weight gain and nutritional status is important during pregnancy since insufficient weight gain and malnutrition can result in low fetal stores of nutrients, impairing

both immune function and fetal growth. Pregnant women living with HIV need to be mindful of appropriate weight gain, but at present there are no specific weight gain recommendations over and above those already established for non-infected women.

Nutrition is important for the mother and for a healthy pregnancy and is also important for protecting the baby from acquiring HIV through vertical transmission from the mother. Adequate nutrition may reduce MTCT by enhancing systemic immune function in the mother and/or the fetus/child. Additionally, adequate nutrition can reduce the rate of clinical, immunological, or virological progression in the mother as well as the viral load (risk of viral shedding) in genital secretions and breast milk. A number of nutrients such as vitamins A, D, E, B6, and B12 may be linked to decreased rates of vertical transmission.

It is assumed that, due to pregnancy and the effects of HIV on the body, pregnant women with HIV have greater nutrient needs. However, insufficient information and guidelines presently exist to provide definitive standards for nutritional care for women with HIV during pregnancy. Advice regarding weight gain, adequate nutrient intake, vitamin supplements, management of HIV-related symptoms and ART side effects, and the risks associated with breastfeeding needs to be readily available to pregnant women with HIV, and proper personalized advice should be provided by a health care professional.

1. Introduction

In North America, one of the fastest growing populations infected with HIV is women, most of whom are of childbearing age (Kunstel, 2008). Therefore, it is necessary to develop ways to improve the health and quality of life of infected pregnant women as well as to prevent MTCT. Ensuring proper nutrition is a key factor in reducing the effects of HIV on the mother and reducing the risk of HIV transmission to the baby. It is assumed that due to pregnancy and the effects of the virus on the body, such women have greater nutrient needs. Currently, insufficient information and guidelines exist to provide definitive standards for nutritional care for women with HIV during pregnancy. Typically, nutritional recommendations for women with HIV are consistent with recommendations for pregnant women in general (Brown, 2007). The current review covers the literature on many of the issues and recommendations pertinent to pregnant women living with HIV.

2. Nutrition and HIV Progression

An individual's nutritional status influences the susceptibility to infectious diseases as well as affecting the disease's outcome. There is support for the idea of improving nutrition in malnourished patients to help bolster the immune response to infection (Santos, 1994). The inherent difficulty with improving nutrition is that any type of infection can result in reduced food intake and nutrient absorption, which then impacts nutritional status (Friis, 2002). Other side effects of an infection, such as fever, mouth sores, and fatigue, as well as side

effects to medications, such as nausea, vomiting, and dry mouth, (Montgomery, 2003) can contribute to malnutrition. In other words, the infection can be mitigated with proper nutrition, but the infection itself may be a significant barrier to healthy nutrition.

Inasmuch as any infection can compromise an individual's nutritional status, chronic viral infections, such as HIV, have particular nutritional challenges. The HIV infection is a progressive virus that includes major metabolic changes in nutrient utilization as the balance of viral replication, immune response, and inflammation changes over time (Sztam & Ndirangu, 2010). As a result, assessment and subsequent correction of nutritional status is being recognized as an important part of comprehensive care of persons infected with HIV (Singhal & Austin, 2002).

Weight loss is a common side effect of being infected with the virus and is usually attributed to increased energy expenditure. Interestingly, although the reason is unknown, several studies have reported that people with HIV tend to burn approximately 10% more calories while resting than those who are uninfected (Batterham, 2005). This HIV-related weight loss and inadequate nutritional intake can lead to *wasting syndrome* (Winson, 2001); an involuntary weight loss of more than 10% of the baseline body weight plus either chronic diarrhea or chronic weakness accompanied by fever (Coodley, Loveless, & Merrill, 1994). Despite advances in HIV treatments, weight loss and wasting continue to be common problems for individuals infected with HIV (Wanke et al., 2000). Some research has found the HIV medication stavudine is associated with an increased risk of wasting (Justice et al., 2004). Although, on the surface, weight loss may not seem too serious, losses of 5-10% of body weight have been connected to an increased risk of illness or death caused by HIV/AIDS (Macallan, 1999; Tang, Jacobson, Spiegelman, Knox, & Wanke, 2005).

In addition to changes to body composition, HIV is also marked by deficiencies in specific nutrients and minerals that influence various immune parameters and are associated with faster disease progression (Baum et al., 1995). Micronutrients are substances that the body requires in small amounts for vital physiological functions. They cannot be synthesized by the body and therefore must be consumed in foods and/or in supplements (Caballero, 2009). According to research, people with HIV are particularly susceptible to micronutrient deficiencies (Friis & Michaelsen, 1998; Singhal & Austin, 2002).

Although the effects of HIV infection on the micronutrient status are likely to be more prevalent among underprivileged populations with low nutrient intake, there is also evidence of micronutrient deficiencies in developed countries. Studies in more affluent countries document that despite typically higher dietary and supplemental intakes of micronutrients, HIV-infected individuals often have low serum concentrations of vitamins A, B6, B12, C, E, folate, carotenoids, selenium, zinc, and magnesium (Baum et al., 1994; Beach et al., 1992; Bogden et al., 1990; Coodley, Nelson & Loveless, 1993; Delmas-Beauvieux et al., 1996; Lacey et al., 1996; Sappey et al., 1994; Singhal & Austin, 2002; Tang, Graham, Chandra, & Saah, 1997; Skurnick et al., 1996). In a study of HIV-1 infected patients, Baum et

al. (1995) concluded that HIV-infected individuals need to pay extra attention to nutrient intake as nutrient levels recommended for the general population are not necessarily adequate for infected individuals.

Essentially, it is postulated that micronutrient deficiencies may enable HIV replication by weakening the immune system resulting in increased viral load. Even so, the evidence remains somewhat inconclusive. There is a possibility that HIV may have effects on the markers used to measure micronutrient levels more than HIV actually affects the amount of micronutrients available in the body (Tang et al., 2005). Further, some studies suggest that ART might play a role in improving micronutrient status (Drain, Kupka, Mugusi, & Fawzi, 2007). Although the relationship between HIV and micronutrients is unclear, there is considerable collective evidence that nutritional compromise adversely affects the course of HIV disease. Moreover, a review by Singhal and Austin (2002) showed that micronutrient supplements for people with HIV may alleviate symptoms, delay progress to AIDS, reduce mortality, accelerate growth in children, improve birth outcomes, and reduce maternal mortality.

3. Nutrition and Pregnancy

Healthy nutrition is important throughout life but particularly so when a woman is pregnant. As pregnancy affects the metabolism of nutrients, maternal diet must provide sufficient energy and nutrients to meet the mother's usual requirements as well as the needs of the growing fetus (Williamson, 2006). If the intake of needed nutrients falls below a certain threshold, fetal growth and development are compromised as is maternal health (King, 2000). With the exception of particular daily supplements, the dietary recommendations for pregnancy are similar to those of nonpregnant women. For example, requirements for protein, folate, niacin, zinc, iron, and iodine are 30–50% higher than before pregnancy (Picciano, 2003). Micronutrient supplements such as iron, folic acid, calcium, vitamin D, and zinc have been reported as being important for fetal growth in populations that are considered typically well-nourished (Erkkola, Karppinen, Järvinen, Knip, & Virtanen, 1998; Mouratidou, Ford, Prountzou, & Fraser, 2006; Turner, Langkamp-Henken, Littell, Lukowski, & Suarez, 2003; Williamson, 2006). In terms of diet quality, there is evidence to show that improved diet quality during pregnancy favours fetal growth, increased birth size, and reduced risks of fetal growth restriction (Rodriguez-Bernal et al., 2010).

In addition to dietary supplements, it is also expected that women should gain some weight during pregnancy, although there is caution about excessive weight gain (Abrams, Altman, & Pickett, 2000). For women with a healthy pre-pregnancy weight, the recommendation for pregnancy weight gain should be between 11.5 and 16.0 kg but varies based on pre-pregnancy BMI score (Rooney & Schauberger, 2002). Weight gain within the recommended limits has been shown to be associated with the lowest risk of complications during pregnancy and labour (Thorsdottir, Torfadottir, Birgisdottir, & Geirsson, 2002) and with a

reduced risk of having a low birth weight infant (Abrams et al., 2000). Thus, appropriate gestational weight gain in combination with extra nutrient consumption is recommended for healthy pregnancy (Institute of Medicine, 1990).

4. Pregnancy, HIV, and Nutrition

The results of a meta-analysis of 31 studies showed that intrauterine growth restriction, preterm delivery, and low birth weight were more common in infants born to mothers living with HIV than to mothers without HIV (Brocklehurst & French, 1998). Although adverse outcomes were more strongly linked to developing countries, negative outcomes were also found in developed countries. Regardless of geography, the additional needs of pregnant women, along with the nutritional consequences of common HIV-related illnesses, infections, and medications (e.g., diarrhea, tuberculosis, appetite loss) put HIV-infected pregnant women at greater nutritional risk than uninfected pregnant women (Piwoz & Bentley, 2005).

In both human and animal studies, nutrient deficiencies during pregnancy have been linked to the immune function of the offspring (Friis, 2002). If not properly managed, nutrient deficiencies caused by HIV can subsequently have effects on the next generation. Some studies have shown that supplements of B-complex vitamins and vitamins C and E can improve the mother's immune status, prevent childhood diarrhea, and enhance pregnancy outcomes. However, the effect of these micronutrients on HIV disease progression and mortality is still being studied (World Health Organization [WHO], 2003).

As of 2003, the World Health Organization declared that there are no specific data on the impact of HIV on the energy needs during pregnancy above those requirements already identified for non-infected women. Thus, it was recommended that energy intake for adults infected with HIV should also apply to pregnant women living with HIV (WHO, 2003). This approach is likely conservative based on the fact that nutritional requirements are often case specific and, therefore, it is difficult to make universal recommendations. Further, some of the research on certain nutrients is inconclusive, or at times contradictory; thus, the effects of several nutrients are still uncertain. Although WHO has made no particular endorsements, the following nutritional recommendations have been highlighted in the medical literature as meriting special attention for women who are pregnant and HIV-positive[1]:

4.1 Macronutrients

As mentioned earlier, HIV infection increases energy needs due to the high rate of resting energy expenditure. Current energy recommendations for pregnant women

[1] The 2003 WHO recommendations are frequently referenced in this review. Although this publication dates nearly a decade ago, a 2011 review of the literature asserts that these recommendations are still reasonable in light of new research (Forrester & Sztam, 2011).

living with HIV are an increase of 10% over baseline energy needs during the asymptomatic phase and an increase of 20-30% above baseline energy needs during the symptomatic phase (Seumo-Fosso & Cogill, 2003). In addition, it is recommended that pregnant women living with HIV ensure an intake of an extra 300 kcal per day during all trimesters of pregnancy (WHO, 1985).

There is a greater need for protein during pregnancy in order to support maternal protein synthesis involved in the expansion of the blood volume, uterus, and breasts to supply amino acids for synthesis of fetal and placental proteins (Kunstel, 2008). Additional protein may be needed for women living with HIV under conditions of stress, such as symptomatic HIV infection, but there is not sufficient evidence to suggest that the presence of the HIV infection per se demands a higher protein intake than that of a non-infected individual (WHO, 2005).

4.2 Micronutrients

4.2.1 Vitamin A

In general, pregnancy is related to an increased risk of vitamin A deficiency for both the mother and newborn (Montgomery, 2003). Some have suggested that vitamin A is important during pregnancy because it can influence the integrity of the vaginal mucosa or placenta (Landers, 1996; Semba, 1994). Further, vitamin A is important for individuals living with HIV, because this micronutrient plays a role in regulating immune function (Kennedy-Oji et al., 2001). Given the combination of pregnancy and HIV-positive status, vitamin A deficiency is more prevalent in pregnant mothers living with HIV than non-infected mothers (Mulu et al., 2011) and has been associated with increased infant mortality (Semba et al., 1995). The benefits of vitamin A supplements on infant and maternal mortality are unclear as there is research suggesting that vitamin A is related to maternal survival (West et al., 1999), yet it may not increase infant survival (Katz et al., 2000).

Vitamin A supplementation during pregnancy was found to reduce the risk of preterm delivery among women infected with HIV (Fawzi et al., 1998). This result may be explained by the gestational weight gain improvements linked to vitamin A supplements (Villamor et al., 2002). Overall, a 2009 review of literature estimated the effect of vitamin A supplementation on infant and maternal mortality and morbidity and explored any side effects for the mother and the new baby. The only strong support for vitamin A supplements was that there is an indication that during pregnancy it can improve birth weight (Wiysonge, Shey, Kongnyuy, Sterne, & Brocklehurst, 2005). Nonetheless, some researchers remain cautious with vitamin A supplementation during pregnancy because of the lack of effectiveness and potential for actually increasing HIV transmission to the baby as found in some studies (Kawai et al., 2010). Thus, it is generally recommended that for women living with HIV, the daily vitamin A intake during pregnancy should not

exceed the daily allowance recommended for any adult (World Health Organization, 2003).

4.2.2 Iron and Folate

Insufficient levels of iron and folate can lead to anemia, which has been linked to low birth weight, preterm delivery, and increased perinatal mortality (Academy for Educational Development, 2004). Friis et al. (2001) studied pregnant women in Zimbabwe living with HIV and reported that several micronutrients were compromised as compared to nonpregnant individuals including levels of folate. Thus, pregnant women with HIV may need to pay special attention to the folate intake above what is recommended for non-infected pregnant women in order to avoid anemia.

There are also additional risks to low iron consumption and HIV. Research suggests that iron status can influence the development of opportunistic infection and the progression of the virus (Delanghe et al., 1998; De Monyé, Karcher, Boelaert, & Gordeuk, 1999; Weinberg, Boelaert, & Weinberg, 2002). However, little information is currently available on how HIV affects the iron balance of pregnant women differently than it affects that of nonpregnant individuals (Montgomery, 2003; Weinberg et al., 2002).

Iron supplementation is often needed in developing countries due to poor dietary conditions, yet in developed countries there is a risk of iron overload (Montgomery, 2003). Too much iron can result in nutrients that support viral replication and that are involved in opportunistic infections (Weinberg et al., 2002). Iron overload can result in pro-oxidant activity, which might accelerate the death of cells and contribute to disease progression (Evans & Halliwell, 2001). Thus, iron supplements should be used with caution and taken in the same dosages as that for uninfected pregnant women (WHO, 2003).

4.2.3 Vitamin D

Vitamin D has been potentially linked to preventing adverse pregnancy outcomes, MTCT of HIV, and child mortality (Mehta et al., 2009). Vitamin D is often recommended in pregnancy as it can contribute to fetal skeletal development through calcium transfer (Specker, 2004), help regulate placental development and function (Evans, Bulmer, Kilby , & Hewison, 2004), and may also contribute to the development of the fetal immune system (Reichrath & Querings, 2005).

Although there is evidence of Vitamin D providing protection from HIV progression, Mehta and colleagues (2009) remarked that there is very little investigation directly examining the association between vitamin D and pregnancy outcomes, MTCT of HIV, or death among children born to women

living with HIV. Their research subsequently focused on the role of nutrient supplements, vitamin D in particular, in women living with HIV pregnancy outcomes. Their results have shown an association between low vitamin D levels and increased HIV disease progression and higher mortality (Viard et al., 2011). While there are no official recommendations, vitamin D supplementation could prove to be an inexpensive method of reducing the burden of HIV infection and death among children, particularly in resource-limited settings (Mehta et al., 2009; Mehta et al., 2010).

4.2.4 Zinc

Adequate zinc levels are essential for good immune function. Research has shown that many people living with HIV have deficient levels of zinc, leading to faster HIV disease progression and an increased risk of death (Baum, Lai, Sales, Page, & Campa, 2010). Baum et al. concluded that zinc therapy could be a safe, simple, and cost-effective tool to improve the immune response and reduce morbidity and should be considered as an adjunct therapy for HIV infection. Similarly, zinc may play a role in improving pregnancy outcomes. A large study of 580 U.S. women with low serum zinc concentrations showed a significant increase in birth weight (+126 g), head circumference (+0.4 cm) and limb length in the group that was supplemented with zinc (Goldenberg et al., 1995). Intuitively, pregnant women who are HIV-positive would benefit from zinc supplementation, but the matter is still uncertain. Villamor et al. (2006) found that zinc supplementation to pregnant women living with HIV offered no benefits on viral load or MTCT. These findings, together with the lack of effect on fetal outcomes, led the authors to conclude that there is insufficient evidence to support the addition of zinc supplements to the standard of prenatal care among women living with HIV. Similarly, Fawzi et al. (2005) highlighted the potential for adverse pregnancy outcomes related to zinc supplementation and the likelihood of negative effects on hemoglobin concentrations. In a recent review of the literature on zinc supplementation, Zeng and Zhang (2011) stated that zinc supplementation seems to be beneficial in terms of change in CD4 count and prevention of opportunistic infection for patients with HIV infection, but it is still unclear whether zinc has any effect on viral load, mortality, MTCT of HIV, and fetal outcomes. However, as most results were from adult trials, they concluded that the safety and efficacy of zinc supplementation in children and pregnant women remain to be ascertained. In 2003, WHO determined that additional research is required to assess the safety of zinc as a nutrient supplement in women infected with HIV compared with uninfected women.

4.2.5 Vitamin Supplementation

While the current review has covered some of the nutrients that have been identified as having potential benefits for pregnant women living with HIV, to

completely tailor nutrient supplementation would be impractical in most cases. Rather, researchers have investigated the advantages of multivitamin supplementation (Montgomery, 2003). Multivitamin supplements such as vitamins B, C, and E have contributed to improvement of CD4 lymphocyte counts and infant birth weight (Fawzi et al., 2000, Fawzi et al., 2004), as well as a reduced risk of growth restriction and severe prematurity (Fawzi et al., 1998; Fawzi et al., 2000; Villamor, 2002). Also, multivitamins can be helpful in regulating weight gain (Villamor et al., 2002). In addition to positive pregnancy outcomes, multivitamin supplements have been related to benefits for the mother, such as reduced chance of developing AIDS, fewer HIV complications (Fawzi et al., 2004), improved immunologic profile and increased R hemoglobin concentrations (Villamor et al., 2002). Women living with HIV should be encouraged to obtain needed nutrients from a balanced diet, but, as this is not always possible, vitamin supplementation is encouraged (Montgomery, 2003; WHO, 2003).

4.3 Food Handling and Eating Patterns

The combination of a compromised immune status attributed to HIV, coupled with further decreases in immune response during pregnancy mean that women with the infection are at high risk of developing foodborne infections during pregnancy (Brown, 2007; Whitney & Rolfes, 2002). Food poisoning can lead to weight loss and further compromise immunity to future infections (Kunstel, 2008). Accordingly, guidelines for handling, storing, and cooking foods should be reinforced, and the risk of infection originating from foods can be decreased if raw/uncooked meats, seafood, unpasteurized milk products, and honey are not consumed (Brown, 2007; Montgomery, 2003). In sum, avoiding the risk of potentially contaminated foods, practicing safe food handling at home, and ensuring hygiene can greatly reduce the risk of foodborne infection (World Bank, 2007)

In addition to food handling, eating patterns contribute to a healthy pregnancy. Some of the symptoms related to HIV and ART may result in nutritional consequences such as anorexia, nausea, vomiting, diarrhea, and chewing and swallowing difficulties (American Dietetic Association and Dietitians of Canada, 2004). Proper dietary management can be an effective way to counteract nutritionally aversive symptoms. Kunstel (2008) recommended the following, depending on the symptoms:

<u>Anorexia</u>

- Eat small, frequent meals.
- Capitalize on moments of hunger. Keep snacks readily available.
- Choose nutrient dense foods (peanut butter, cheese, yogurt).
- Avoid foods of low nutrient value (diet foods and beverages).

Nausea and vomiting

- Keep something in the stomach to curb nausea (i.e., crackers).
- Choose bland foods that are easy to digest such as toast, pasta, oatmeal, turkey, and pudding.
- Avoid greasy, high fat foods.
- Avoid spicy or highly seasoned foods.

Diarrhea

- Select binding (diarrhea inhibiting) foods such as bananas, toast, rice, and applesauce.
- Avoid high fat foods and lactose-containing foods.
- Drink adequate fluids to replace losses (water, sports drink, juices).

Sore mouth and throat

- Select smooth textured foods, such as pudding, yogurt, scrambled eggs, bananas, and applesauce.
- Avoid foods that are acidic, spicy, and have rough edges and textures.
- Add moisture to foods with broths and gravies.
- Use a straw to drink liquids.

Lastly, pregnant women who suffer gastrointestinal problems due to HIV treatment medications can be encouraged to eat small, frequent meals throughout the day, consume liquids between meals instead of with meals, and snack on crackers (Sherman, & Sherman, 2001).

4.4 Weight Gain

Given that body composition is an important factor in the health of both mother and baby, determining the influence of HIV on body composition is important. Notably, the dietary concern of wasting during pregnancy may be more common in women living with HIV than in the general population (Grinspoon et al., 1998; Villamor et al., 2002) since high plasma viral load has been connected with lower lean and fat body mass during pregnancy (Friis, Gomo, & Michaelsen, 2002). Weight loss during pregnancy is likely to occur at the expense of maternal rather than fetal tissues, yet wasting can cause stillbirth, preterm delivery, and intrauterine growth restriction (Mehta et al., 2008; Villamor, Dreyfuss, Baylin, Msamanga & Fawzi, 2004).

Insufficient weight gain and malnutrition during pregnancy can result in low fetal stores of some nutrients, impairing immune function and fetal growth. Consequently, the young infant is more vulnerable to being infected with HIV (Piwoz & Bentley, 2005; Villamor et al., 2005). Data strongly suggest that wasting can affect gestational outcomes. Pregnant women living with HIV need to be mindful of appropriate weight in

light of their HIV status, but at present there are no weight gain recommendations over and above those identified for non-infected women (WHO, 2003).

4.5 Mother-to-Child Transmission (MTCT)

MTCT of HIV is the primary way that children become infected with HIV, and transmission may be indirectly related to the mother's nutritional status (Semba, 1997). MTCT may occur through several avenues including transplacental, intrapartum, or breastfeeding transmission (Dreyfuss & Fawzi, 2002). It has been suggested that adequate nutritional status may reduce MTCT by affecting several maternal or fetal/child risk factors for transmission such as enhancing systemic immune function in the mother or fetus/child; reducing the rate of clinical, immunological, and/or virological progression in the mother; reducing viral load (lowering the risk of viral shedding in genital secretions and breast milk); reducing the risks of low birth weight and prematurity; and/or by maintaining the fetus/child gastrointestinal integrity (Fawzi, 2000). In addition, poor nutritional status (pre-existent or as a result of HIV-induced wasting or weight loss) is likely to increase the risk of MTCT of HIV (Villamor et al., 2005). That is, maintaining a healthy nutritional status inhibits disease progression and HIV complications in the mother, which reduces the likelihood that the infection can be perinatally transmitted.

There have been several studies suggesting that low serum A levels of vitamin A among pregnant women living with HIV is associated with a higher risk of MTCT (Graham et al., 1993; Greenberg et al., 1997; Semba et al, 1994; Semba et al., 1995).). Conversely, there is contradicting evidence where no correlation to MTCT was found (Villamor et al., 2010, Burger et al., 1997; Burns et al., 1999; Fawzi et al., 2002). There is the possibility that serum A levels may be a marker of, rather than a causal factor for, advanced stages of HIV disease. On the other hand, different diets as well as lengths of follow-up time or other predictors of transmission among vitamin-deficient and vitamin-sufficient groups could be explanations for these disparate findings (Fawzi, 2000). The inconsistency of these results means that vitamin A supplementation is not generally recommended for pregnant women living with HIV as a preventative measure for MTCT (Wiysonge et al., 2005)

It has been speculated that other micronutrient deficiencies in vitamins E, B6, and B12 as well as riboflavin, copper, and zinc may also contribute to vertical transmission (Semba et al., 1994). However, Fawzi (2000) asserts that findings from randomized, controlled trials suggest that supplements of vitamin A or any other vitamins are unlikely to have an effect on MTCT during pregnancy or the intrapartum period. Further, Fawzi recognized that the effect of other nutrient supplements, such as zinc and selenium, is unknown. Since the review, Mehta and colleagues (2008) explored the role of malnutrition as it relates to anemia and found a correlation between anemia and MTCT. They subsequently recommended testing of protein-energy and micronutrient

supplements as an intervention to anemia in order to improve pregnancy outcomes and reduce MTCT. In another study, Mehta et al. (2009) investigated the role of vitamin D in MTCT and found that women with low levels of vitamin D were more likely to vertically transmit HIV. Thus, the research in this area is ongoing and no official recommendations have been issued.

5. Postpartum Nutrition

Infectious complications have been found to be more common during the postpartum period in women living with HIV (Fiore, Newell, & Thorne, 2004). Consequently, vitamin supplementation should continue for three months postpartum in order to maintain a healthy nutritional status that can combat infection (Montgomery, 2003). Otherwise, no particular recommendations have been provided for women living with HIV in postpartum.

A mother's nutritional status is important for feeding her infant, yet breastfeeding is a complex issue for mothers living with HIV and can be both harmful and helpful depending on the situation. HIV can be vertically transmitted through breast milk and, therefore, current practice is that breastfeeding is strongly discouraged and should be avoided when possible (Kayira et al., 2012). Acknowledging the complexity of the issue, the WHO (2001) recommends that mothers living with HIV avoid breastfeeding in instances where replacement milk is acceptable, feasible, affordable, sustainable, and safe. However, WHO also recognizes that breastfeeding is the social norm and essential to the survival of the infant in many parts of the world for both HIV-positive and HIV-negative mothers. Despite the concern about HIV transmission to the infant from breastfeeding, use of replacement milks in developing countries is principally considered unacceptable, unaffordable, or unsafe (Coutsoudis, Goga, Rollins, & Coovadia, 2002; Kiarie, Richardson, Mbori-Ngacha, Nduati, & John-Stewart, 2004; Latham & Preble, 2000). As a result, breastfeeding likely will remain the norm for mothers living with HIV in most of Africa, for example, regardless of the effect of lactation on HIV transmission.

Unfortunately, the WHO nutritional guidelines are not always implemented effectively, leading to inappropriate infant-feeding choices and consequent lower infant HIV-free survival. Therefore, breastfeeding counselling should take into account individual and environmental criteria to support appropriate infant-feeding choices (Doherty et al., 2007). Breastfeeding is necessary despite the risk of HIV where there are no other alternatives for the nutrition of the infant. Conversely, where proper substitutes for breast milk can be obtained, using formula is the safe and prudent manner to feed the child.

6. Conclusion

Ensuring proper nutrition is a critical component of living with HIV as it is with being pregnant. The two conditions combined mean that pregnant women living with HIV is a

population that is especially vulnerable to nutrient deficiencies and these women must monitor their nutritional status accordingly. Although some evidence remains inconclusive or requires further research, some general recommendations are applicable. Pregnant women living with HIV need to sustain adequate weight gain during pregnancy and be cautious of wasting. It is essential to ensure adequate nutrient intake by having good dietary habits and monitoring appropriate macronutirent and micronutrient intake. Due to increased susceptibility to illness, implementing safe food handling practices and preventing foodborne illnesses is imperative. Advice regarding weight gain, adequate nutrient intake, vitamin supplements, management of HIV-related symptoms, and the risks associated with breastfeeding should be made available to pregnant women living with HIV, and proper personalized advice should be provided by a physician. In developing a nutrition care plan, the best outcomes for both the mother and developing child are promoted.

References

Abrams, B., Altman, S.L., & Pickett, K.E. (2000). Pregnancy weight gain: Still controversial. *American Journal of Clinical Nutrition, 71*, 1233S–1241S.

Academy for Educational Development. (2004). *HIV/AIDS: A guide for nutritional care and support* (2nd ed.).Washington, DC: Academy for Educational Development.

American Dietetic Association and Dietitians of Canada. (2004). Position of the American Dietetic Association and Dietitians of Canada: Nutrition intervention in the care of persons with human immunodeficiency virus infection. *Journal of the American Dietetic Association, 104*, 1425–1440.

Batterham, M.J. (2005). Investigating heterogeneity in study of resting energy expenditure in persons with HIV/AIDS: A meta-analysis. *American Journal of Clinical Nutrition*, *81,* 702-713.

Baum, M., Cassetti, L., Bonvehi, P., Shor-Posner, G., Lu, Y., & Sauberlich, H. (1994). Inadequate dietary intake and altered nutrition status in early HIV-1 infection. *Nutrition, 10*, 16-20.

Baum, M., Shor-Posner, G., Lu, Y., Rosner, B., Sauberlich, H. E., Fletcher, M. A., . . . Hennekens, C. H. (1995). Micronutrients and HIV-1 disease progression. *AIDS, 9*, 1051-1056.

Baum, M.K., Lai, S., Sales, S., Page, J.B., & Campa, A. (2010). Randomized, controlled clinical trial of zinc supplementation to prevent immunological failure in HIV-infected adults. *Clinical Infectious Disease, 50,* 1653-1660.

Beach, R. S., Morhan, R., Wilkie, F., Mantero-Atienza, E., Blaney, N., Shor-Posner, G.,…Baum, M. K. (1992) Plasma vitamin B12 level as a potential cofactor in studies of human immunodeficiency virus type 1-related cognitive changes. *Archives of Neurology, 49*, 501-506.

Bogden, J.D., Baker, H., Frank, O., Perez, G., Kemp, F. Bruening, K., & Louria, D. (1990). Micronutrient status and human immunodeficiency virus (HIV) infection. Annals of the New York Academy of Sciences, *587*, 189–95.

Brocklehurst, P. & French, R. (1998). The association between maternal HIV infection and perinatal outcome: a systematic review of the literature and meta-analysis. *British Journal of Obstetrics and Gynaecology, 105*, 836-848.

Brown, J.E. (2007). *Nutrition through the life cycle* (3rd ed.). Belmont, CA: Thomson Wadsworth.

Burger, H., Kovacs, A., Weiser, B., Grimson, R., Nachman, S., Tropper, P., . . . Blaner, W.S. (1997). Maternal serum vitamin A levels are not associated with mother-to-child transmission in the United States. J*ournal of acquired immune deficiency syndromes and human retrovirology, 14*, 321-326.

Burns, D.N., FitzGerald, G., Semba, R., Hershow, R., Zorrilla, C., Pitt, J., . . . Landesman, S. (1999). Vitamin A deficiency and other nutritional indices during pregnancy in human immunodeficiency virus infection: Prevalence, clinical correlates, and outcome. Women and Infants Transmission Study Group. *Clinical Infectious Diseases, 29*, 328-334.

Caballero, B. (2009). *Guide to nutritional supplements*. Boston, MA: Elsevier.

Coodley, G. O., Loveless, M. O., & Merrill, T. M. (1994). The HIV wasting syndrome: A review. *Journal of Acquired Immune Deficiency Syndromes, 7*, 681–694

Coodley, G. O., Nelson, H. D., Loveless, M. O., & Folk, C. (1993). Beta-Carotene in HIV Infection. *Annals of the New York Academy of Sciences, 691*, 277–278

Coutsoudis, A., Goga, A.E., Rollins, N., & Coovadia, H.M. (2002). Free formula milk for infants of HIV-infected women: blessing or curse? *Health Policy Plan*, *17*, 154-160.

Delanghe, J., Langlois, M., Boelaert, J.R., Van Acker, J., Van Wanzeele, F., van der Groen G., . . . Plum, J.(1998). Haptoglobin polymorphism, iron metabolism and mortality in HIV infection. *AIDS, 12,* 1027-1032.

Delmas-Beauvieux, M.C., Peuchant, E., Couchouron, A., Constans, J., Sergeant, C., Simonoff, M., . . . Clerc, M. The enzymatic antioxidant system in blood and glutathione status in human immunodeficiency virus (HIV)-infected patients: effects of supplementation with selenium or beta-carotene. *American Journal of Clinical Nutrition, 64*, 101-107.

De Monyé, C., Karcher, D.S., Boelaert, J.R., & Gordeuk, V.R. (1999). Bone marrow macrophage iron grade and survival of HIV-seropositive patients. *AIDS, 13*, 375-380.

Doherty, T., Chopra, M., Jackson, D., Goga, A., Colvin, M., & Persson, L.A. (2007). Effectiveness of the WHO/UNICEF guidelines on infant feeding for HIV-positive women: Results from a prospective cohort study in South Africa. *AIDS. 21,* 791–797.

Drain, P. K., Kupka, R., Mugusi, F., & Fawzi, W.W. (2007). Micronutrients in HIV-positive persons receiving highly active antiretroviral therapy. *American Journal of Clinical Nutrition, 85*, 333-345.

Dreyfuss, M.L., & Fawzi, W.W. (2002). Micronutrients and vertical transmission of HIV-1. *American Journal of Clinical Nutrition, 75,* 959-70.

Erkkola, M., Karppinen, M., Järvinen, A., Knip, M., & Virtanen, S. (1998). Folate, vitamin D, and iron intakes are low among pregnant Finnish women. *European Journal of Clinical Nutrition*, *52*, 742–8.

Evans, K.N., Bulmer, J.N., Kilby, M.D., & Hewison, M. (2004). Vitamin D and placental-decidual function. *Journal of the Society for Gynecologic Investigation, 11*, 263-271.

Evans, P., & Halliwell, B., (2001). Micronutrients: oxidant/antioxidant status. *British Journal of Nutrition, 85,* S67–S74.

Fawzi, W.W. (2000) Nutritional factors and vertical transmission of HIV-1: Epidemiology and potential mechanisms. *Annals of New York Academy of Science, 918*, 99–114.

Fawzi, W. W., Msamanga, G. I., Hunter, D., Renjifo, B., Antelman, G., Bang, H., . . . Mwakagile, D. (2002). Randomized trial of vitamin supplements in relation to transmission of HIV-1 through breastfeeding and early child mortality. *AIDS, 16*, 1935-1944.

Fawzi, W.W., Msamanga, G.I., Spiegelman, D., Urassa, E.J., McGrath, N., Mwakagile, M., . . . Hunter, D.J. (1998). Randomized trial of effects of vitamin supplements on pregnancy outcomes and T cell counts in HIV-1-infected women in Tanzania. *Lancet, 351,* 1477–1482.

Fawzi, W., Msamanga, G., Hunter, D., Urassa, E., Renjifo, B., Mwakagile, D.,…Spiegelman D. (2000). Randomised trial of vitamin supplements in relation to vertical transmission of HIV-1 in Tanzania. *Journal of AIDS, 23*, 246–254.

Fawzi, W.W., Msamanga, G., Spiegelman, D., Wei, R., Kapiga, S., Villamor, E., . . . Hunter, D.J. (2004). A randomized trial of multivitamin supplements and HIV disease progression and mortality. *New England Journal of Medicine, 351*, 23-32.

Fawzi, W.W., Villamor, E., Msamanga, G. I., Antelman, G., Aboud, S., Urassa, W. & Hunter, D. J. (2005). A trial of zinc supplements in relation to pregnancy outcomes, hematologic indicators, and T cell counts among HIV-1-infected women in Tanzania. *The American Journal of Clinical Nutrition, 81*, 161-167.

Fiore, S., Newell, M.L., & Thorne, C. (2004). Higher rates of post-partum complications in HIV-infected than in uninfected women irrespective of mode of delivery. *AIDS,18*, 933–938.

Forrester, J.E., & Sztam, K.A. (2011). Micronutrients in HIV/AIDS: is there evidence to change the WHO 2003 recommendations? *American Journal of Clinical Nutrition. 94*, 1683S-1689S

Friis, H. (2002). Micronutrients & HIV infection. Boca Raton, FL: CRC Press.

Friis, H., Gomo, E., Koestel, P., Ndhlovu, P., Nyazema, N., Krarup, H., & Michaelsen K. F. (2001). HIV and other predictors of serum folate, serum ferritin, and hemoglobin in pregnancy: A cross-sectional study in Zimbabwe. *American Journal of Clinical Nutrition*, *73*, 1066–1073.

Friis, H., Gomo, E., & Michaelsen, K. F. (2002). Micronutrient interventions and the HIV pandemic. In H. Friis (Ed.), *Micronutrients and HIV Infection* (pp. 219–246). Boca Raton, FL: CRC Press.

Friis, H., Gomo, E., Nyazema, N., Ndhlovu, P., Kaestel, P., Krarup, H., & Michaelsen, K. F. (2002). HIV-1 viral load and elevated serum alpha (1)-antichymotrypsin are independent predictors of body composition in pregnant Zimbabwean women. *Journal of Nutrition, 132,* 3747-3753.

Friis, H., Michaelsen, K.F. (1998). Micronutrients and HIV infection: A review. *European Journal of Clinical Nutrition, 52,* 157-163.

Goldenberg, R. L., Tamura, T., Neggers, Y. H., Copper, R. L., Johnston, K. E., DuBard, M. B., & Hauth, M. D. (1995). Effect of zinc supplementation on pregnancy outcome. *The Journal of the American Medical Association, 274,* 463–468.

Graham, N., Bulterys, M., Chao, A., Humphrey, J., Clement, L., Dushimmana, A., . . . Saah, A. (1993). Effect of maternal vitamin A deficiency on infant mortality and perinatal HIV transmission. Paper presented at the National Conference on Human Retroviruses and Related Infection, Baltimore, MD.

Greenberg, B.L., Semba, R.E., Vink, P.E., Farley, J.J., Sivapalasingam, M., Steketee, R.W., . . . Schoenbaum, E.E. (1997). Vitamin A deficiency and maternal-infant transmission of HIV in two metropolitan areas in the United States. *AIDS, 11*, 325-332.

Grinspoon, S., Corcoran, C., Miller, K., Wang, E., Hubbard, J., Schoenfeld, D., . . . Kilbanski, A. (1998). Determinants of increased energy expenditure in HIV-infected women. *American Journal of Clinical Nutrition, 68*, 720-725.

Institute of Medicine. (1990). *Nutrition during pregnancy.* Washington, DC: National Academy Press.

Justice, A. C., Stein, D. S., Fusco, G. P., Sherrill, B. H., Fusco, J. S., Danehower, S. C.,...Graham, N.M. (2004). Disease progression in HIV-infected patients treated with stavudine vs. zidovudine. *Journal of Clinical Epidemiology, 57*, 89-97. doi: 10.1016/s0895-4356(03)00245-2.

Katz, J., West, K. P., Jr, Khatry, S. K., Pradhan, E. K., LeClerq, S. C., Christian, P.,… Sommer, A. (2000). Maternal low-dose vitamin A or beta-carotene supplementation has no effect on fetal loss and early infant mortality: a randomized cluster trial in Nepal. *American Journal of Clinical Nutrition, 71*, 1570-1576.

Kawai, K., Kupka, R., Mugusi, F., Aboud, S., Okuma, J., Villamor, E., . . . Fawzi, W.W. (2010). A randomized trial to determine the optimal dosage of multivitamin supplements to reduce adverse pregnancy outcomes among HIV-infected women in Tanzania. *American Journal of Clinical Nutrition, 91,* 391–397.

Kayira, D., Bentley, M.E., Wiener, J., Mkhomawanthu, C., King, C.C., Chitsulo, P.,…Adair, L. (2012). A lipid-based nutrient supplement mitigates weight loss among HIV-infected women in a factorial randomized trial to prevent mother-to-child transmission during exclusive breastfeeding. *American Journal of Clinical Nutrition, 95*, 759-765.

Kennedy-Oji, C., Coutsoudis, A., Kuhn, L., Pillay, K., Mburu, A., Stein, Z., & Coovadia, H. (2001). Effects of vitamin A supplementation during pregnancy and early lactation on body weight of South African HIV-infected women. *Journal of Health, Population and Nutrition, 19,* 167–176.

Kiarie, J.N., Richardson, B.A., Mbori-Ngacha, D., Nduati, R. W., & John-Stewart, G.C. (2004). Infant feeding practices of women in a perinatal HIV-1 prevention study in Nairobi, Kenya. *Journal of Acquired Immune Deficiency Syndrome*, *35*, 75-81.

King, J.C. (2000). Physiology of pregnancy and nutrient metabolism. *American Journal of Clinical Nutrition, 71,* 1218S-1225S.

Kunstel, K. (2008). AIDS/HIV in pregnancy. In C.J. Lammi-Keefe, S.C. Couch, E.H. Philipson (Eds), *Handbook of nutrition and pregnancy* (pp. 161-174). Totowa, NJ: Editorial Humana Press.

Lacey, C.J., Murphy, M.E., Sanderson, M.J., Monteiro, E.F., Vail, A., Schorah, C.J. (1996). Antioxidant-micronutrients and HIV infection. *International Journal of STDs & AIDS, 7,* 485–489.

Landers, D.V. (1996). Nutrition and immune function II: Maternal factors influencing transmission. *Journal of Nutrition*, *126,* S2637-S2640.

Latham, M.C., & Preble, E.A. (2000). Appropriate feeding methods for infants of HIV infected mothers in sub-Saharan Africa. *British Medical Journal, 320*, 1656-1660.

Macallan, D.C. (1999). Wasting in HIV infection and AIDS. *Journal of Nutrition, 129,* 238S-242S.

Mehta, S., Giovannucci, E., Mugusi, F.M., Spiegelman, D., Aboud, S., Hertzmark, E., & Fawzi, W.W. (2010). Vitamin D status of HIV-infected women and its association with HIV disease progression, anemia, and mortality. *PLoS One, 5,* e8770.

Mehta, S., Hunter, D.J., Mugusi, F.M., Spiegelman, D., Manji, K.P., . . . Fawzi, W.W. (2009). Perinatal outcomes, including mother-to-child transmission of HIV, and child mortality and their association with maternal vitamin D status in Tanzania. *Journal of Infectious Disease, 200*, 1022–30.

Mehta, S., Manji, K.P., Young, A.M., Brown, E.R., Chasela, C., Taha, T.E., . . . Fawzi, W.W. (2008). Nutritional indicators of adverse pregnancy outcomes and mother-to-child transmission of HIV among HIV-infected women. *The American Journal of Clinical Nutrition, 87,* 1639-1649.

Montgomery, K. S. (2003). Nutrition and HIV-positive pregnancy. *Journal of Perinatal Education, 12,* 42-47.

Mouratidou, T., Ford, F., Prountzou, F., & Fraser, R. (2006). Dietary assessment of a population of pregnant women in Sheffield, UK. *British Journal of Nutrition*, *96*, 929–35.

Mulu, A., Kassu, A., Huruy, K., Tegene, B., Yitayaw, G., Nakamori, M., . . . Ota, F. (2011). Vitamin A deficiency during pregnancy of HIV infected and non-infected women in tropical settings of Northwest Ethiopia. *BMC Public Health, 11*, 569.

Picciano, M.F., (2003). Pregnancy and lactation: Physiological adjustments, nutritional requirements and the role of dietary supplements. *Journal of Nutrition, 133*, 1997S-2002S.

Piwoz, E.G., & Bentley, M.E. (2005). Women's voices, women's choices: The challenge of nutrition and HIV/AIDS. The *Journal of Nutrition, 135*, 933-937.

Reichrath, J., & Querings, K. (2005). Vitamin D deficiency during pregnancy: A risk factor not only for fetal growth and bone metabolism but also for correct development of the fetal immune system? *The American Journal of Clinical Nutrition, 81*, 1177.

Rodriguez-Bernal, C.L., Rebagliato, M., Iniguez, C., Vioque, J., Navarrete-Muñoz, E.M., Murcia, M.,.. . . Ballester, F. (2010). Diet quality in early pregnancy and its effects on fetal growth outcomes: The Infancia y Medio Ambiente (Childhood and Environment) Mother and Child Cohort Study in Spain. *The American Journal of Clinical Nutrition, 91*, 1659–1666.

Rooney, B.L., Schauberger, C.W. (2002). Excess pregnancy weight gain and long-term obesity: One decade later. *Obstetrics and Gynecology*, *100*, 245–252.

Santos, J. I. (1994). Nutrition, infection, and immunocompetence. *Infectious Disease Clinics of North America, 8*, 243-267.

Sappey, C., Leclercq, P., Coudray, C., Faure, P., Micoud, M. & Favier, A. (1994). Vitamin, trace element and peroxide status in HIV seropositive patients: Asymptomatic patients present a severe β-carotene deficiency. *Clinica Chimica Acta, 230,* 35–42

Semba, R.D. (1994). Vitamin A, immunity and infection. *Clinical Infectious Diseases*, *19,* 489-499.

Semba, R. D. (1997). Vitamin A and human immunodeficiency virus infection. *Proceedings of the Nutrition Society, 56*, 459-469.

Semba, R. D., Miotti, P. G., Chiphangwi, J. D., Liomba, G., Yang, L. P., Saah, A. J., . . . Hoover, D.R. (1995). Infant mortality and maternal vitamin A deficiency during human immunodeficiency virus infection. *Clinical Infectious Diseases, 21*, 966-972.

Semba, R.D., Miotti, P.G., Chiphangwi, J.D., Saah, A.J., Canner, J.K., Dallabetta, G.A., & Hoover, D.R. (1994). Maternal vitamin A deficiency and mother-to-child transmission of HIV-1. *Lancet, 343*, 1593-1597.

Seumo-Fosso, E., & Cogill, B. (2003). *Meeting nutritional requirements of HIV-infected persons*. Washington, D.C.: Academy for Educational Development.

Sherman, D., & Sherman, N. (2001). HIV/AIDS and pregnancy. In C. A. Kirton, D. Talotta, & K. Zwolski (Eds.), *Handbook of HIV/AIDS Nursing* (pp. 361–379). St. Louis, MO: Mosby.

Singhal, N., & Austin, J. (2002). A clinical review of micronutrients in HIV Infection. *Journal of the International Association of Physicians in AIDS Care (Chic), 1*, 63–75.

Skurnick, J.H., Bogden, J.D., Baker, H., Kemp, F.W., Sheffet, A., Quattrone, G., & Louria, D.B. (1996). Micronutrient profiles in HIV-1-infected heterosexual adults. *Journal of Acquired Immune Deficiency Syndromes& Human Retrovirology, 12,* 75–83.

Specker, B. (2004). Vitamin D requirements during pregnancy. *American Journal of Clinical Nutrition, 80,* 1740S-1747S.

Sztam, K. A., & Ndirangu, M. (2010). HIV and Nutrition. In A. Bendich & R. J. Deckelbaum (Eds.), *Preventive Nutrition* (pp. 611-640). Totowa, NJ: Humana Press.

Tang, A.M., Graham, N.M.H., Chandra, R.K., & Saah, A.J. (1997). Low serum vitamin B-12 concentrations are associated with faster human immunodeficiency virus type 1 (HIV-1) disease progression. *Journal of Nutrition, 127,* 345-51.

Tang, A.M., Jacobson, D.L., Spiegelman, D., Knox, T.A., & Wanke, C. (2005). Increasing risk of 5% or greater unintentional weight loss in a cohort of HIV-infected patients, 1995 to 2003. *Journal of Acquired Immune Deficiency Syndromes, 40,* 70–76.

Thorsdottir, I., Torfadottir, J.E., Birgisdottir, B.E., & Geirsson, R.T. (2002). Weight gain in women of normal weight before pregnancy: Complications in pregnancy or delivery and birth outcome. *Obstetrics and Gynecology*, *99*, 799–806.

Turner, R.E., Langkamp-Henken, B., Littell, R., Lukowski, M., & Suarez, M. (2003). Comparing nutrient intake from food to the estimated average requirements shows middle- to upper-income pregnant women lack iron and possibly magnesium. *Journal of the American Dietetic Association*, *103*, 461–6.

Viard, J.P., Souberbielle, J.C., Kirk, O., Reekie, J., Knysz, B., Losso, M., . . . Mocroft, A. (2011). Vitamin D and clinical disease progression in HIV infection: Results from the EuroSIDA study. *AIDS, 25*, 1305-1315.

Villamor, E., Aboud, S., Koulinska, I.N., Kupka, R., Urassa, W., Chaplin, B., . . . Fawzi, W.W. (2006). Zinc supplementation to HIV-1-infected pregnant women: Effects on maternal anthropometry, viral load, and early mother-to-child transmission. *European Journal of Clinical Nutrition, 60*, 862–869.

Villamor, E., Dreyfuss, M.L., Baylin, A., Msamanga, G., & Fawzi, W.W. (2004). Weight loss during pregnancy is associated with adverse pregnancy outcomes among HIV-1 infected women. *Journal of Nutrition, 134*, 1424–1431.

Villamor, E., Koulinska, I.N., Aboud, S., Murrin, C., Bosch, R.J., Manji, K.P., & Fawzi, W.W. (2010). Effect of vitamin supplements on HIV shedding in breast milk. *American Journal of Clinical Nutrition, 92*, 881-886.

Villamor, E., Msamanga, G., Spiegelman, D., Antelman, G., Peterson, K.E., Hunter, D.J., & Fawzi, W.W. (2002). Effect of multivitamin and vitamin A supplements on weight gain during pregnancy among HIV-1-infected women. *The American Journal of Clinical Nutrition*, *76*, 1082–90.

Villamor, E., Saathoff, E., Msamanga, G., O'Brien, M.E., Manji, K., & Fawzi, W.W. (2005). Wasting during pregnancy increases the risk of mother-to-child HIV-1 transmission. *Journal of Acquired Immune Deficiency Syndromes, 38,* 622– 6.

Wanke, C. A., Silva, M., Knox, T. A., Forrester, J., Speigelman, D., & Gorbach, S. L. (2000). Weight Loss and Wasting Remain Common Complications in Individuals Infected with Human Immunodeficiency Virus in the Era of Highly Active Antiretroviral Therapy. *Clinical Infectious Diseases, 31*, 803-805.

Weinberg, G.A., Boelaert, J.R., Weinberg, E.D. (2002) Micronutrients and HIV infection. In: H. Friis (Ed), *Iron and HIV infection* (pp.135-158). *Boca Raton, FL*: *CRC Press*.

West, K.P. Jr., Katz, J., Khatry, S.K., Leclerq, S.C., Pradhan, E.K., Shrestha, S.R., . . . Sommer, A. (1999). Double blind, cluster randomised trial of low dose supplementation with vitamin A or β-carotene on mortality related to pregnancy in Nepal. *BMJ, 318*, 570-575.

Whitney, E. N., Rolfes, S. R. (2002). Understanding nutrition. (9th ed.). Belmont, CA: Wadsworth.

Williamson, C.S. (2006). Nutrition in pregnancy. *Nutritional Bulletin, 31, 28-59.*

Winson, S.K.G. (2001). Management of HIV – associated diarrhoea and wasting. *Journal of the Association of Nurses in AIDS Care, 12,* 55-62.

Wiysonge, C.S., Shey, M., Kongnyuy, E.J., Sterne, J.A.C., & Brocklehurst, P. (2005). Vitamin A supplementation for reducing the risk of mother-to-child transmission of HIV infection. *Cochrane Database Systematic Reviews,* (4), CD003648.

World Bank. (2007).*HIV/AIDS, nutrition, and food security: What we can do.* Washington, DC: World Bank.

World Health Organization. (1985). *Energy and protein requirements* (Technical report series 724). Geneva: World Health Organization.

World Health Organization. (2001). *New Data on the Prevention of Mother-to-child Transmission of HIV and Their Policy Implications: Conclusions and Recommendations* (Report no. WHO/RHR/01.28.) Geneva: World Health Organization.

World Health Organization. (2003). *Nutrient requirements for people living with HIV/AIDS: Report of a technical consultation, World Health Organization, Geneva, 13-15 May 2003.* Geneva: World Health Organization.

World Health Organization. (2005). *Nutrition and HIV/AIDS: Report by the secretariat.* Geneva: World Health Organization.

Zeng, L., & Zhang, L. (2011). Efficacy and safety of zinc supplementation for adults, children and pregnant women with HIV infection: Systematic review. *Tropical Medicine & International Health*, 16, 1474-1482.