Introduction

Pregnancy is a critical stage of development during which maternal nutrition can strongly influence obstetric and neonatal outcomes (Godfrey et al., 1996; Kramer, 2003). Optimal nutrition is necessary to maintain the health of the mother, to help ensure a normal, healthy delivery, and also to reduce the risk of birth defects, sub-optimal foetal development and chronic health problems in childhood (American Dietetic Association, 2008).

Poor nutritional status and sub-optimal pre- and antenatal care are common in developing countries, often resulting in pregnancy complications and poor obstetric outcomes (Hampshire et al., 2004). Pregnant women in Sub-Saharan Africa (SSA) are at particular nutritional risk as a result of poverty, food insecurity, political and economic instabilities, frequent infections, and frequent pregnancies (Lartey, 2008). The main nutritional issues impacting these women include maternal under- and over-nutrition and deficiencies of key pregnancy micronutrients, such as iron, folate, calcium, vitamin D and vitamin A. Consequently, poor obstetric outcomes, such as anaemia, neural tube defects (NTDs), rickets, low birth weight (LBW) and maternal and neonatal mortality, are common in SSA.
SSA is a region of intensive migration prompted by adverse economic, political and ecological conditions. Consequently, SSA immigrants represent a sizeable and growing immigrant population in many Western countries. For example, of the 4.6 million recorded Africans living in the European Union, at least one-third are from SSA and approximately 250,000 of these immigrants are living in the UK (Kohnert, 2007). Several studies have reported that pregnant women of African origin are one of the immigrant groups at highest risk of pregnancy complications, such as hypertension and diabetes (Salvador et al., 2010), and adverse birth outcomes, including preterm delivery, low birth weight infants, caesarean delivery and perinatal mortality (Carolan, 2010; Urquia et al., 2010). Although the exact causes of such outcomes have not yet been clearly identified, it is possible that poor premigration health and nutritional status, high parity, closely-spaced pregnancies, pre-existing diseases and lower socioeconomic status in the host countries are contributing factors (Carolan, 2010). However, it should be noted that the majority of African migrants to Western countries are from the higher socioeconomic groups and, thus, one would expect them to be healthy and well-nourished compared to the general populations of their native countries. In such cases, adoption of typical Western diets and lifestyles may worsen the nutritional status of immigrant SSA women (Satia, 2010) by predisposing them to obesity, which carries its own risk for pregnancy complications (Leddy et al., 2008).

SSA is a geographically and culturally diverse region consisting of many different countries. Nigeria is the most populous country in Africa and, in recent decades, it has become increasingly involved in international migration to Europe, the USA and the Gulf States. As a result, Nigerians now represent the most common SSA-born immigrants in many Western countries (de Haas, 2006; Kent, 2007). Furthermore, a large body of literature is available in the area of nutrition and pregnancy resulting from research in Nigeria. For these reasons, the present review focuses on the case of Nigeria aiming to review the literature on the common nutritional inadequacies and associated complications among pregnant women in SSA and, second, to discuss the possible implications of immigration on the nutritional status and obstetric outcomes among these women in the Western world.

A wide range of international studies have been considered for this review. Searches of the PubMed, EMBASE and CINAHL databases were performed using the keywords: nutrition or diet with pregnancy and Sub-Saharan Africa or Nigeria, pregnancy outcomes with Sub-Saharan Africa or Nigeria or immigrants, immigrants with nutrition or diet. Reviews, intervention studies and observational studies were included. Relevant references obtained in the literature were further reviewed to identify additional studies on this topic. Only studies in English were included.

Traditional foods and food groups consumed in Nigeria

Foods are traditionally classified in Nigeria according to the physiological functions that they are considered to perform, in compliance with the Federal Government’s Nutrition Curriculum Guidelines (National Health Planning Directorate, 1979). Cereals, grains, starchy fruits, roots and tubers are classified as ‘energy-giving foods’ and form the basis of most meals (Alade, 1985; Ogunjuyigbe et al., 2008). The ‘body-building’ food group consists of meat, fish, shellfish, snails, eggs, soya cake, legumes, seeds and pulses, whereas traditional ‘protective foods’ include banana, plantain, okra, egg and walnut (Ogunjuyigbe et al., 2008). Other foods, such as various fruits and vegetables, may be considered among Nigerians as optional supplementary foods and are given lower priority in the diet (Alade, 1985), despite being important sources of vitamins, minerals and fibre. Meals often take the form of spicy soups and stews containing meat or fish and these are served with a large portion of starchy carbohydrate food. Palm oil and groundnut oil are commonly used in cooking to add colour and flavour to dishes; however, these are high in saturated fat (Thomas & Bishop, 2007).

Nutrient intakes and nutritional status of Nigerian women

There is an absence of available national nutrient intake data among the Nigerian population. However, various independent studies have examined the nutrient intakes of pregnant and nonpregnant Nigerian women in Nigeria, among different age groups and geographical locations. A summary of the results of some of the more recent studies are reported in Table 1, along with the percentage recommended dietary allowances achieved for each micronutrient. Because of the absence of data on weights, body mass index (BMI) and gestational stage of the women in each of these studies, it is difficult to assess the overall adequacy of energy and macronutrient intakes. However, the energy intakes of the pregnant urban and rural women in the study by Oguntona & Akinanye (2002) are obviously inadequate because neither group exceeds a mean daily intake of 6 MJ (1434 kcal per day), yet the joint Food and Agriculture Organisation (FAO), World Health Organization (WHO) and United Nations University (UNU) Expert Consultation on energy requirements recommend that a nonpregnant woman weighing 60 kg with a low level of activity consumes 8.3 MJ per
Carbohydrate intake as a percentage of total energy was very high among both urban (74%) and rural (72%) pregnant women in this study and it was reported that most foods were derived from three main food groups, namely roots and tubers, cereals and legumes (Oguntona & Akinyele, 2002).

The data in Table 1 provide evidence of clear disparities between the dietary patterns of the rural Fulani (semi-nomadic pastoralists) and the urban market non-pregnant women. Again, it appears that the energy intake of the rural women is inadequate, especially given the typically active and labour-intensive lifestyles of this group (Glew et al., 2001). Almost 50% of their energy is derived from fat (Table 1), which is typical of the Fulani diet because it contains large amounts of dairy, palm oil and butter. Despite this, Glew et al. (2001) reported an optimal lipid profile in this group of adults, indicative of a low cardiovascular disease risk, which may be attributed to their active lifestyle and low total energy intake. By contrast, the urban market women have a much higher energy intake, which is likely to exceed their requirements given their typically sedentary lifestyle, as demonstrated by Afolabi et al. (2004).

The Nigeria Demographic and Health Survey (NDHS) was carried out by the National Population Commission (NPC) Nigeria and Inner City Fund (ICF) Macro in 2008. This nationally representative survey recorded anthropometric measurements of weight and height in a sample of 33 385 nonpregnant Nigerian women from across the country, aged 15–49 years, aiming to determine nutritional status as indicated by BMI and short stature (height <145 cm). The results of these measurements are summarised in Table 2.

Short stature and low prepregnancy BMI are risk factors for obstetric complications and maternal and neonatal morbidity as well as mortality in developing countries (Black et al., 2008). Although the data in Table 2 indicate that the highest proportion of short stature women occurs in the 15–19-year-old age group, this may be influenced by incomplete growth among adolescents. However, the highest rate of underweight also occurs in the youngest age group (19.3%), which is of particular concern regarding pregnancy and neonatal outcomes given that the median age of first birth in Nigeria is estimated to be 20.4 years (NPC Nigeria and ICF Macro, 2009).

LBW (birth weight <2.5 kg) is an important predictor of infant morbidity and mortality (Godfrey & Barker, 2000) and its prevalence is approximately 8% in Nigeria (NPC Nigeria & ICF Macro, 2009). Poor maternal nutrition and inadequate gestational weight gain likely account for a large proportion of this growth retardation

### Table 1

<table>
<thead>
<tr>
<th>Reference</th>
<th>Subjects</th>
<th>Setting</th>
<th>Method of dietary assessment</th>
<th>Energy MJ per day</th>
<th>Protein (% TE)</th>
<th>CHO (% TE)</th>
<th>Fat (% TE)</th>
<th>Calcium mg per day (% RDA)</th>
<th>Iron mg per day (% RDA)</th>
<th>Folate</th>
<th>Vitamin B12 lg per day (% RDA)</th>
<th>Vitamin A lg per day (% RDA)</th>
<th>Vitamin B6 mg per day (% RDA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oguntona &amp; Akinyele</td>
<td>101 pregnant women, &gt;17 years</td>
<td>Urban</td>
<td>3-day weighed intake</td>
<td>5.7</td>
<td>11</td>
<td>74</td>
<td>17</td>
<td>739.5 (62)</td>
<td>11.8 (46)</td>
<td>177.0 (29.5)</td>
<td>2339 (292)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rural</td>
<td>3-day weighed intake</td>
<td>5.9</td>
<td>12</td>
<td>72</td>
<td>16</td>
<td>609.4 (51)</td>
<td>10.9 (43)</td>
<td>183.0 (30.5)</td>
<td>2411 (301)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Glew et al. (2001)</td>
<td>79 nonpregnant Fulani women, 15–77 years</td>
<td>Rural</td>
<td>Dietary recall over 7 days</td>
<td>6.2</td>
<td>17</td>
<td>37</td>
<td>49</td>
<td>871.0 (87)</td>
<td>11.0 (55)</td>
<td>126.0 (31.5)</td>
<td>721 (144)</td>
<td>4.7 (196)</td>
<td>-</td>
</tr>
<tr>
<td>Oguntona &amp; Tella</td>
<td>87 nonpregnant market women, &lt;49 years</td>
<td>Urban</td>
<td>24 hr recall on 2 consecutive days</td>
<td>10.4</td>
<td>13</td>
<td>67</td>
<td>24</td>
<td>5520 (65)</td>
<td>11.6 (58)</td>
<td>-</td>
<td>1565 (13)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>TE, total energy: CHO, carbohydrate.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

This is supported by the low energy intake among pregnant women reported by Ogun-tona & Akinyele (2002) (Table 1). A study involving 840 pregnant women by Ojofeitimi et al. (2008) reported that the majority achieved less than 80% of the recommended energy intake.

The nutritional status and micronutrient intake of Nigerian women in pregnancy is discussed in more depth below, and the implications of various nutrient deficiencies (as commonly cited among Nigerian women) on pregnancy outcomes will be highlighted.

Maternal under-nutrition and food aversion

The causes of maternal under-nutrition in developing countries, such as Nigeria, are multidimensional and multifactorial. Some of the main factors involved include the low status of women, which denies them appropriate decision-making power and access to contraception, resulting in frequent and closely-spaced pregnancies. A high level of female illiteracy exists, which is a proxy for poor health-seeking behaviour among Nigerian women. Furthermore, the high rate of poverty that predominantly affects women leads to inadequate dietary intakes and reduced access to adequate general and maternity health services (Ogunjuyigbe et al., 2008). However, in addition to these issues, traditional beliefs regarding foods to be avoided during pregnancy have been considered as a major factor limiting the quality of dietary intake among Nigerian women (Ojofeitimi & Tanimowo, 1980). The most common foods reported to be avoided in pregnancy are ‘energy-giving foods’, such as cassava, rice and yam, followed by ‘body-building foods’ (e.g. meat, snail, egg, liver) and various types of fruit (Ogunjuyigbe et al., 2008). The variety of meats avoided denies pregnant women of some of the cheapest sources of high quality protein, which may contribute to malnutrition (Ojofeitimi et al., 1982; Sanusi & Oredipe, 2002). Although Ojofeitimi et al. (2008) found adequate protein intake among the majority of their pregnant Nigerian subjects, there was preponderance for protein of plant origin, which has a lower biological value.

The main reasons reported for avoiding certain foods during pregnancy in Nigeria are taboo, stomach pains, nausea/vomiting and the effect on the baby’s size (Ogunjuyigbe et al., 2008) because there is a fear that the birth of large babies increases the risk for caesarean section (Ojofeitimi et al., 1982). Strong aversion to surgical delivery is common in developing countries as a result of social misconception, religious views, and fear of surgical complications and cost, even in the context of obstetric emergencies (Sheridan et al., 2011).

Maternal obesity and being overweight

The NDHS 2008 reported that obesity and being overweight is more prevalent among older women, those with greater education and wealth and those living in urban areas (Table 2). The rise in obesity and subsequent risk of chronic diseases in Nigeria is primarily indicative of a ‘nutrition transition’, that is, the shift from traditional diets and lifestyles to ‘Western’ diets that are high in saturated fats, sugar and refined foods, together with reduced levels of physical activity and increased stress (Popkin, 1994). Growing trends in obesity rates in developing countries also have implications for pregnancy outcomes. Being overweight or obese before and during pregnancy increases the risk of gestational diabetes mellitus (GDM), pregnancy-induced hypertension, pre-eclampsia, congenital defects, abnormal labour and the need for an emergency caesarean section (Leddy et al., 2008).

Although few studies have specifically examined the effects of maternal obesity on pregnancy outcomes in Nigerian or other African populations, those that do exist

Table 2 Nutritional status of Nigerian women aged 15–49 years: the percentage with height <145 cm and with specific body mass index (BMI) (kg m\(^{-2}\)) levels by age and area of residence

<table>
<thead>
<tr>
<th>Background characteristic</th>
<th>&lt;145 cm</th>
<th>&lt;18.5 kg m(^{-2})</th>
<th>18.5–24.9 kg m(^{-2})</th>
<th>25–29.9 kg m(^{-2})</th>
<th>&gt;30 kg m(^{-2})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15–19</td>
<td>6.1</td>
<td>19.3</td>
<td>73.7</td>
<td>6.0</td>
<td>1.0</td>
</tr>
<tr>
<td>20–29</td>
<td>2.6</td>
<td>11.6</td>
<td>70.0</td>
<td>14.4</td>
<td>3.9</td>
</tr>
<tr>
<td>30–39</td>
<td>1.9</td>
<td>9.5</td>
<td>60.1</td>
<td>20.7</td>
<td>9.7</td>
</tr>
<tr>
<td>40–49</td>
<td>1.8</td>
<td>9.2</td>
<td>57.0</td>
<td>23.5</td>
<td>10.3</td>
</tr>
<tr>
<td>Residence</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>2.1</td>
<td>9.1</td>
<td>60.1</td>
<td>30.8</td>
<td>9.5</td>
</tr>
<tr>
<td>Rural</td>
<td>3.5</td>
<td>14.0</td>
<td>69.0</td>
<td>17.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Total</td>
<td>3.0</td>
<td>12.2</td>
<td>65.7</td>
<td>22.1</td>
<td>6.0</td>
</tr>
</tbody>
</table>

Adapted from National Democratic and Health Survey 2008 (NPC & ICF Macro, 2009).
have reported similar pregnancy complications and outcomes to those reported in non-African populations. In a study of Nigerian women by Anorlu et al. (2005), greater body weight was significantly associated with risk of pre-eclampsia. Studies on obesity among pregnant South African women have reported increased risks of various complications, including GDM, urinary tract infections, induction of labour, delivery by caesarean section and miscarriage (Ngoga et al., 2009; Basu et al., 2010).

Iron deficiency and anaemia

Anaemia in pregnancy is a global problem and is significantly associated with maternal and infant morbidity and mortality (WHO, 1992; Ugwuja et al., 2010). However, its prevalence is particularly high in developing countries, where it may occur in up to 61% of pregnant women (WHO, 1994). Table 3 summarises the results of various studies on the prevalence of anaemia among pregnant Nigerian women. The wide variance in anaemia rates reported may be attributed to differences in study methodologies (e.g. inclusion/exclusion criteria for supplement users), gestation at time of diagnosis, definition of anaemia, socio-economic status and the presence of parasitic or other infections.

Iron deficiency is considered as the most common cause of anaemia in Sub-Saharan Africa (VanderJagt et al., 2007), although other nutrient deficiencies and diseases may also be contributing factors. The prevalence of iron deficiency among pregnant Nigerian women in Nigeria has been reported to vary from 44–64% (International Institute of Tropical Agriculture, 2004; VanderJagt et al., 2007; Ugwuja et al., 2010). As already noted, a high intake of plant as opposed to animal protein is common, which is associated with a low intake of dietary iron (Oguntona & Akinyele, 2002; Ojofeitimi et al., 2008). In addition, the intestinal absorption of any dietary iron that is consumed is likely to be reduced as a result of the high intake of phytates from grains, such as millet and sorghum (VanderJagt et al., 2007). As maternal iron requirements increase in pregnancy, it is difficult to maintain iron balance through diet alone and the prevention of iron deficiency anaemia (IDA) therefore depends on adequate maternal iron stores early in pregnancy. However, if iron stores are already depleted, it is very difficult to replenish them once pregnancy is in progress (Okwu & Ukooha, 2008).

In an effort to control IDA in pregnancy, the Nigerian government health system has embarked on routine iron-folate supplementation commencing from the second trimester (Nair et al., 2004). These supplements provide 200 mg per day of ferrous sulphate and 5 mg per day of folic acid. However, the effectiveness of this programme in Nigeria has been significantly reduced by noncompliance (Ejidokun, 2000). An investigation into the attitudes of pregnant Nigerian women towards anaemia and supplementation identified the major influences on compliance: poor perception of maternal anaemia as a priority health problem, poor knowledge of signs of anaemia and symptoms and associated maternal complications and fear of severe blood loss at or after delivery, which is assumed by some women to be caused by iron (Ejidokun, 2000).

It is important to recognise, however, that anaemia among pregnant Nigerian women may have multiple causes, including iron, folate and B_{12} deficiencies, parasitic infections (malaria and hookworms), HIV/AIDS and haemoglobinopathies (van den Broek, 1996). Deficiencies of copper, zinc and vitamin A may also be contributing factors because these micronutrients are involved in erythropoiesis and iron metabolism (Bloom et al., 1990). The multifactorial nature of anaemia was demonstrated by Ugwuja et al. (2010), who identified an inverse relationship between iron deficiency and anaemia in a population of pregnant Nigerian women, indicating the role of some other factors that were not identified in the study.

Folate, vitamin B_{12} and neural tube defects

Inadequate dietary intakes of folate have been reported among Nigerian pregnant and nonpregnant women (Table 1). Folate plays an important role in foetal development and a low folate status in pregnancy increases the risk of preterm delivery and LBW (Scholl & Johnson, 2000). Folate supplementation in pregnancy has been shown to reduce the incidence of NTDs in the offspring (Czeizel & Dudas, 1992). However, few studies have investigated the folate status of pregnant women in Nigeria. VanderJagt et al. (2007) reported that 14% of anaemic women had a sub-normal serum folate concentration, although this was not significantly different from the sub-normal folate prevalence among non-anaemic women. In a study by VanderJagt et al. (2009), three of their pregnant subjects had a serum folate level below the lower limit of the reference range for pregnant women, despite reporting that they were taking folate supplements. It has been previously considered that the routine antenatal supplementation of folic acid in Nigeria will compensate for inadequacies in its dietary consumption (Ojofeitimi et al., 2008). However, the issue of noncompliance must be considered, as with the case of antenatal iron supplementation (Ejidokun, 2000).

There is a high prevalence of NTDs in SSA, with reported figures ranging from 0.16–7 per 1000 live births (Rabiu, 2009). This is in comparison with a prevalence of 0.45–1 per 1000 (EUROCAT, 2009) and 0.6–1.3 per 1000 (Marks & Khoshnood, 1998) live births in Europe and...
# Table 3

Summary of studies on the prevalence of anaemia, marginal vitamin A status and vitamin A deficiency (VAD) among pregnant women in Nigeria

<table>
<thead>
<tr>
<th>Reference</th>
<th>Geographical region</th>
<th>Subjects (n)</th>
<th>Sociodemographic Characteristics</th>
<th>Anaemia prevalence (%)</th>
<th>Definition of anaemia</th>
<th>Predisposing factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Idowu et al. (2005)</td>
<td>Abeokuta, SW</td>
<td>477</td>
<td>Not reported</td>
<td>76.5</td>
<td>Hb &lt;11.0 g dL⁻¹</td>
<td>Primigravidae, ANC at traditional birth home</td>
</tr>
<tr>
<td>Dim &amp; Onah (2007)</td>
<td>Enugu, SE</td>
<td>530</td>
<td>Not reported</td>
<td>40.4</td>
<td>Hb &lt;11.0 g dL⁻¹</td>
<td>HIV positive, late booking for ANC</td>
</tr>
<tr>
<td>VanderJagt et al. (2007)</td>
<td>Gombe, NE</td>
<td>146</td>
<td>61% no formal education</td>
<td>30.0</td>
<td>Hb &lt;10.5 g dL⁻¹</td>
<td>Iron deficiency</td>
</tr>
<tr>
<td>Bukar et al. (2008)</td>
<td>Gombe, NE</td>
<td>461</td>
<td>Primarily low SES, 4% third level education</td>
<td>51.8</td>
<td>PCV &lt;30%</td>
<td>Low SES, late booking for ANC</td>
</tr>
<tr>
<td>Ugwuja et al. (2010)</td>
<td>Abakaliki, SE</td>
<td>349</td>
<td>34% third level education, 41% work in civil service</td>
<td>72.2</td>
<td>Hb &lt;11.0 g dL⁻¹</td>
<td>Multiparity, &lt;10 ANC attendances</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Reference</th>
<th>Geographical region</th>
<th>Subjects (n)</th>
<th>Sociodemographic Characteristics</th>
<th>Prevalence of marginal vitamin A status (%)</th>
<th>Definition of marginal vitamin A status</th>
<th>Prevalence of clinical VAD (%)</th>
<th>Definition of VAD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ajobe et al. (2004)</td>
<td>Calabar Urban, SE</td>
<td>200</td>
<td>Not reported</td>
<td>37.0</td>
<td>Plasma retinol 0.35–0.7 µmol L⁻¹</td>
<td>17.5</td>
<td>Plasma retinol &lt;0.35 µmol L⁻¹</td>
</tr>
<tr>
<td>Maziya-Dixon et al. (2004)</td>
<td>National</td>
<td>1080</td>
<td>48% no formal education, &gt;40% farming occupation</td>
<td>19.2</td>
<td>Serum retinol &lt;30 µg dL⁻¹</td>
<td>8.8</td>
<td>Serum retinol &lt;20 µg dL⁻¹</td>
</tr>
<tr>
<td>Williams et al. (2008)</td>
<td>Osun, SW</td>
<td>101</td>
<td>Mixed backgrounds</td>
<td>32.7</td>
<td>Serum retinol 10–19 µg dL⁻¹</td>
<td>15.8</td>
<td>Serum retinol &lt;20 µg dL⁻¹</td>
</tr>
</tbody>
</table>

SE, south-east; NE, north-east; SW, south-west; Hb, haemoglobin; PCV, packed cell volume; ANC, antenatal care; HIV, human immunodeficiency virus; SES, socio-economic status; VAD, vitamin A deficiency.
the USA, respectively. To our knowledge, there is no national register in Nigeria on the NTD prevalence, although empirical evidence suggests that it is a major health problem, particularly among low-income families where access to quality health care and maternity services is poor (Adeleye et al., 2010). Ugwu et al. (2007) reported an NTD prevalence of 1.3% among babies born to mothers in a Nigerian teaching hospital, all of whom received and consumed folic acid supplements from the second trimester of pregnancy, as per the national iron-folate supplementation policy. However, it was noted that none of the women received folic acid preconceptionally, which is crucial for the prevention of NTDs (Wilson et al., 2007).

Unfortunately, preconceptional folic acid supplementation is not a routine recommendation of the Nigerian health system and a recent survey of Nigerian women of reproductive age suggests that awareness and acceptance of the importance of such supplementation is poor (Egwurudjakpor et al., 2011). It is therefore more likely that a national policy of folic acid fortification of a staple food would be effective in combating the high NTD rates in Nigeria, as has been recommended by researchers in this field (Adeleye et al., 2010). Such a policy does not yet exist in Nigeria or many other SSA countries; however, Nigeria is included on the agenda of the Global Initiative to Eliminate Folic Acid-Preventable-Neural Tube Defects through mandatory folic acid fortification, which is being run by the Centre for Disease Control and Prevention.

NTDs may also be the result of vitamin B$_{12}$ deficiency, independent of the mother’s folate status (Simpson et al., 2010). Studies are very limited with respect to the vitamin B$_{12}$ status and dietary intakes of the Nigerian population. It can be seen in Table 1 that Glew et al. (2001) reported particularly high intakes of the vitamin among Fulani women, which may be attributed to their high intake of dairy products. However, intake of animal products tends to be much lower in other areas of Nigeria, and a chronic low intake of the vitamin may increase the risk of subclinical deficiency (Carmel & Sarrai, 2006). The only available studies investigating the prevalence of subclinical vitamin B$_{12}$ deficiency among pregnant Nigerian women have reported figures of 8–10% (VanderJagt et al., 2007, 2009). In addition to NTDs, inadequate vitamin B$_{12}$ status during pregnancy may also result in pre-eclampsia and impaired neurological function in the infant (Simpson et al., 2010).

**Calcium, vitamin D and infantile rickets**

Calcium and vitamin D are important micronutrients during pregnancy to ensure adequate mineralisation of foetal bone and for maintenance of maternal bone density (Specker, 2004). The calcium and vitamin D status of Nigerian women and their infants has come under scrutiny in recent decades as a result of a high prevalence of rickets in the country. Akpede et al. (1999) reported a prevalence of overt rickets of 2.4% and a prevalence of abnormalities suggestive of rickets of 14.9% among Nigerian households in the Sahel-Savannah region.

Data from Table 1 indicate that the dietary calcium intake of pregnant and nonpregnant Nigerian women is inadequate. Sanchez et al. (1997) reported that, toward the end of gestation, calcium deficiency existed among pregnant teenagers in northern Nigeria. In many parts of Nigeria, the typical diet is largely devoid of dairy products and rich in phytates and oxalates that chelate calcium (Thacher et al., 1999). Furthermore, many sources of calcium in the Nigerian diet are plant-based, which have poor bioavailability (Oguntona & Akinyele, 2002). However, it is not clear whether dietary calcium deficiency causes any specific problems in pregnancy as a result of the normal physiological adaptations to increase calcium absorption during this period (Prentice, 1994).

Maternal vitamin D deficiency is associated with an increased risk of pre-eclampsia (Bodnar et al., 2007) and vitamin D deficiency in the newborn, predisposing infants to the development of rickets (Dawodu & Wagner, 2007). The practice of purdah (i.e. the use of veils by women) among Muslim Nigerian women may significantly affect their vitamin D status, through deprivation of sunlight exposure. Glew et al. (2010) reported that 83% of Muslim Nigerian women in their study had a serum 25-hydroxyvitamin D [25(OH)D] concentration in the insufficient or deficient range. Okonofua et al. (1986) found that pregnant purdah clad women in Nigeria had lower plasma levels of calcium and phosphate and lower serum 25(OH)D levels than their nonpurdah Nigerian counterparts. However, the 25(OH)D concentrations of both groups of Nigerian women were still higher than that of Caucasian women in the UK. The higher incidence of rickets and tetany among Nigerian infants was queried compared to that occurring in Caucasian infants in the UK, highlighting the lower serum calcium concentrations among the purdah-clad Nigerian women as a likely contributing factor, which may be linked to a genetic predisposition (Okonofua et al., 1986).

Although there is limited literature on the calcium and vitamin D status of pregnant Nigerian women and subsequent pregnancy outcomes, it appears that members of this population are at risk of deficiencies of either or both of these micronutrients (Okonofua et al., 1986; Sanchez et al., 1997; Oguntona & Akinyele, 2002; Ojofeitimi et al., 2008; Glew et al., 2010). This is likely to have an effect on foetal bone development and may influence the high incidence of rickets among Nigerian children.
Vitamin A deficiency

Vitamin A deficiency (VAD) is recognised as a serious public health problem in Nigeria (Williams et al., 2011) and pregnant women appear to be particularly susceptible to this deficiency, perhaps as a result of the physiological demand of increased blood volume (Ajose et al., 2004). Pregnancy outcomes that have been associated with VAD in Nigeria and other developing countries include stillbirth, pre-eclampsia, maternal night-blindness, maternal IDA and mother-to-child transmission of HIV (Radhika et al., 2002; van den Broek et al., 2010; Williams et al., 2011). A systematic review by van den Broek et al. (2010) did not reveal a role for antenatal vitamin A supplementation for the prevention of maternal or perinatal mortality, preterm birth or LBW. However, supplementation was associated with a reduced risk of maternal night-blindness and a reduction in maternal anaemia, particularly in populations with a high prevalence of VAD and HIV.

Table 3 summarises the findings of several studies on the prevalence of VAD among pregnant and nonpregnant Nigerian women. A low level of education and higher parity have been identified as the main risk factors for VAD among pregnant women in Nigeria (NPC Nigeria and ICF Macro, 2009; Williams et al., 2011).

Vitamin A requirements increase in pregnancy by approximately 100 μg retinol equivalents (RE) per day. The WHO therefore recommend that pregnant women achieve an intake of 800 μg RE per day (FAO/WHO, 2004), which is similar to UK and US recommendations. VAD may result from habitual dietary inadequacy; however, the widespread prevalence of infections in Nigeria, which suppress plasma vitamin A levels, are also likely to play a role. For example, in the study by Ajose et al. (2004), 10% of pregnant women had symptoms of fever and the malaria parasite was identified in one-third of these patients, which may explain the higher rates of VAD and marginal vitamin A status (Table 3). Ojoefotimi et al. (2008) reported that 100% of Nigerian women in their study, both pregnant and nonpregnant, failed to meet the recommended dietary intake of vitamin A. By contrast, Williams et al. (2008) and Oguntona & Akinyele (2002) reported mean dietary vitamin A intakes among pregnant women that were significantly higher than the FAO/WHO (2004) recommended intake. However, dietary vitamin A in both these studies came primarily from carotenoid sources, such as dark leafy vegetables. Thus, their apparently high intakes may be compromised by the poor bioconversion of pro-vitamin A to active vitamin A (Castenmiller & West, 1998). Furthermore, cooking practices such as boiling green vegetables and heating palm oil to very high temperatures before adding them to stews are likely to reduce the vitamin A content and bioavailability of some of the richest sources of the vitamin in the Nigerian diet (Ajose et al., 2004).

Sub-Saharan African immigrants in the Western world

In 2005, the International Organisation on Migration (IOM) reported that there are 4.6 million African immigrants living in Europe and about 890,000 in the USA (IOM, 2005). Of those living in Europe, approximately one-third originate from SSA and, of these, West African immigrants from Nigeria, Ghana and Senegal contribute the largest proportion (Kohnert, 2007). Similarly, in the USA, the largest percentage of African-born immigrants hail from West Africa (37%) and Nigeria is the overall top-sending country of African immigrants (Kent, 2007).

Popular European destinations among SSA immigrants include the UK, France, Germany, Belgium and the Netherlands, whereas the Gulf States are also popular. Since the 1990s, Spain, Italy and Ireland have also emerged as major destinations of labour migrants from West Africa, particularly Nigeria (de Haas, 2006; Kohnert, 2007). In 2007, the Nigerian immigrant population of the UK was approximately 75,000 (almost 2% of the immigrant population), representing a steady increase from previous years and the ninth largest immigrant group in the country (Dobson et al., 2010). The 2006 Irish census reported a total of 16,300 Nigerians living in Ireland (almost 4% of immigrant population), representing an 82% increase on the 2002 figure (Central Statistics Office, 2006).

The reasons for migration from SSA are not confined to an escape from poverty and economic and political upheaval in the native countries. External pull factors, such as improved employment and educational prospects, are considered to play a major role in current migration trends (Kohnert, 2007). In the case of Nigerian immigrants, the UK and USA generally attract highly educated and skilled workers, such as health professionals (de Haas, 2006). Furthermore, labour migration from Nigeria and other SSA countries has become increasingly feminine (de Haas, 2006), which could potentially increase the number of SSA immigrant women seeking antenatal care in Western countries.

Published data are lacking on the numbers of babies born to women of different nationalities in Western countries. However, it is likely that pregnant Nigerian women make up a significant proportion in the USA and parts of Europe given the prevalence of Nigerians compared to other immigrant nationalities in these countries. Although many SSA women living in developed countries are assumed to be from higher socioeconomic groups,
Maternal nutrition among women from Sub-Saharan Africa

K. L. Lindsay et al.

and therefore presumably well-nourished, studies have still reported that they have high rates of poor obstetric outcomes compared to the native women of the host countries. For example, a study of pregnancy outcomes among various immigrant women living in Finland revealed that SSA women had the highest rates of caesarean delivery (40.5%; \( P < 0.001 \)) and perinatal mortality (29.6 per 1000 births; \( P < 0.001 \)) compared to all other immigrant groups (Malin & Gissler, 2009). The rate of preterm birth was also high among SSA women in this study (6.5%) and was only exceeded by women of Vietnamese (7.6%), South Asian (8.0%) and Middle Eastern/North African (8.1%) origin. Meanwhile, Urquia et al. (2010) reported that the risk of giving birth to an infant of LBW is 1.75-fold greater among SSA-born women living in Europe compared to European-born women (95% confidence interval = 1.44–2.12). This risk was also greater than all other immigrant groups studied, except for women from South-central Asia (odds ratio = 1.84).

However, there is a paucity of literature investigating the nutritional and general health status and dietary intakes of these women, whether pregnant or nonpregnant. Barriers to antenatal care, such as communication difficulties, lower socioeconomic status, delay in seeking antenatal care and poor attendance to scheduled appointments, have also been implicated to increase the risk of adverse pregnancy outcomes among immigrants (Malin & Gissler, 2009). However, there are limited data in this area specific to SSA women and, thus, the links between these critical factors and poor pregnancy outcomes among SSA immigrant women remain to be determined.

Dietary acculturation among immigrant groups in the Western world

Many studies have examined the impact of immigration on the dietary patterns of various immigrant groups, such as Latin Americans (Ayala et al., 2008), Asians (Pan et al., 1999), North Africans (Méjean et al., 2007) and African Caribbeans (Desilets et al., 2007). Dietary acculturation is the process that occurs when members of a minority group adopt the eating patterns/food choices of the host country (Satia, 2010). This is a multidimensional, dynamic and complex process in which immigrants may retain and find new ways to use traditional foods, exclude others and consume ‘new’ foods.

Dietary acculturation does not necessarily result in improved nutritional outcomes. Rather, many studies have found it to have adverse effects on the diets of immigrants and ethnic minorities, placing them at an elevated risk for diet-related chronic diseases (Satia, 2010; Ayala et al., 2008). This is understandable considering the ‘Western’ diets of many developed countries, which are typically high in saturated fat, refined sugar and processed meats. Delisle (2010) demonstrated the adoption of Western-style diets among immigrants of African descent in Madrid and Montreal. In both cases, the ‘healthfulness’ score of the adopted Western diets was significantly lower than that of the immigrants’ traditional diets, although the effects of this dietary acculturation on health outcomes were not investigated.

In reality, dietary acculturation does not result in a clear dichotomous classification of dietary patterns among immigrants (i.e. Western versus traditional/prudent) (Satia, 2010). Often, a transitional dietary pattern will exist between these two, which may contain both positive and negative nutritional components. For example, in one of the only studies investigating the diets of immigrant Nigerians, Kumar et al. (2009) reported that Nigerian men living in the USA had a higher fruit and wholegrain intake, lower tobacco use and intake of trans fats and a higher physical activity level than their indigenous Nigerian counterparts. However, a greater intake of meats, oils and alcohol and a reduction in fish intake among the immigrants were negative aspects of their diets, which may be detrimental to their health (Kumar et al., 2009).

Satia (2010) concludes that, among immigrants of African origin, traditional diets tend to be healthier than the dietary patterns evolving from globalisation, urbanisation and acculturation. This may be attributed to the high intake of protective food groups in the traditional diets, such as legumes, wholegrains, fruits and vegetables, with a concomitant low intake of ‘unhealthy’ food groups, such as highly processed meats, salty and high-fat snacks, and sweetened beverages. Such changes in dietary patterns may have particular consequences in pregnancy given the importance of optimal nutrition at this time. However, the impact of acculturation on the dietary patterns and nutrient intakes of pregnant African immigrant women has yet to be investigated.

Suggestions for further research

There is a vast paucity in the literature in relation to the nutritional intakes of pregnant women in Western countries, originating from SSA. This is not surprising given that the diets and nutrient intakes of African immigrants in general have been under-studied to date. Based on findings from studies of pregnant women in Nigeria, immigrant SSA women should be considered as a potential high-risk group on presentation to maternity hospitals in developed countries. There is an urgent need for research to determine these risks and how they should be tackled. Specific issues that could be addressed include the dietary patterns, nutrient intakes and supplement use.
of SSA immigrant women in the Western world, both during and outside of pregnancy, so that their risk of specific nutrient deficiencies can be ascertained, at the same time as taking cultural and dietary preferences into account. The incidence and severity of pregnancy complications and adverse outcomes should also be investigated in these immigrant groups, along with their associations with diet, nutritional status, socioeconomic status and attendance for antenatal care services. Such research would not only contribute to early detection and treatment of high nutritional risk pregnant women from SSA in the antenatal setting, but also would assist in the delivery of tailored nutritional advice based on the typical diets that are consumed by SSA pregnant women living in the Western world.

Conclusions

Poor nutritional status in pregnancy is common in developing countries for a variety of reasons, including poverty, food insecurity, sub-optimal healthcare and frequent infections. Pregnant women in SSA have been reported to suffer a wide range of nutritional deficiencies, pregnancy complications and adverse obstetric and neonatal outcomes. Although under-nutrition is still prevalent in SSA, many countries are concurrently experiencing a nutrition transition with a consequent rise in obesity and chronic diseases. Both extremes in nutritional status have implications for pregnancy outcomes and the future health of offspring. Immigration of Sub-Saharan African women to Western countries has increased in recent decades; however, the impact of immigration on their nutritional status and pregnancy outcomes has not been investigated. If the nutritional inadequacies seen in SSA persist post-migration, then these women would constitute a particularly high-risk group for adverse outcomes and should be considered as such on presentation to antenatal clinics in their host countries. Further research is therefore required to determine the nutritional status and associated obstetric risks of this growing immigrant population group.

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References


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