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Obesity and the nutrition transition in Sub-Saharan Africa

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This review illustrates the outcomes of the nutrition transition in Sub-Saharan Africa (SSA) and its association with overweight and obesity; the relationship with the double burden of malnutrition is also explored. We describe the increase in overweight in nearly all Sub-Saharan African countries and present data on associated increased gross domestic product, and availability of energy, protein, fat, and sugar at country national levels. Predictors of overweight are described by means of various studies undertaken in SSA, and dietary intakes of numerous countries are presented. Overall, we show that socioeconomic status, gender, age, parity, physical inactivity, and increased energy, fat, and sugar intake are powerful predictors of overweight and/or obesity. The urgency for health interventions in countries in the early stages of the nutrition transition is emphasized, particularly in view of the fact that fat intake is still less than 30% of energy intake in nearly all Sub-Saharan African countries.

Keywords: nutrition transition; obesity, noncommunicable diseases; Sub-Saharan Africa; diet; nutrition

Introduction

Overweight and obesity are important risk factors for cardiovascular diseases (CVD), type 2 diabetes, certain cancers, and musculoskeletal disorders—the so called chronic noncommunicable diseases (NCDs)—and are hence of great public health concern.[1] Globally, some 2.8 million people die annually as a result of being overweight and obese, and about 35.8 million disability-adjusted life years are caused by overweight and obesity. In Africa, some 27% of adults aged 20 years and over are overweight, and 8% are obese.[1]

Finucane *et al.*[2] estimated worldwide trends in adult population mean body mass index (BMI) in 199 countries using a Bayesian hierarchical model to estimate BMI by age and country based on representative studies. They determined that, between 1980 and 2008, mean BMI increased by 0.4 kg/m^2 for men and 0.5 kg/m^2 for women. The United States had the highest BMI increase of the high-income countries. Female BMI was lowest in Bangladesh and male BMI was lowest in Congo. Hence, it is clear that over the past 30 years mean BMI has been steadily increasing even in low and middle-income countries, including those in Sub-Saharan Africa (SSA).

Around 1975 to date, urbanization has been increasing steadily in SSA accompanied by a massive growth of industry, especially that of food manufacturing in urban areas of Africa.[3,4] This has resulted in the emergence and popularization of, for example, soft drinks and fast foods and many Western brand names on the continent. In many urban areas, such Western food items were regarded as desirable status symbols, rapidly inculcated by local inhabitants, and widely consumed. These products are disproportionately expensive in relation to average incomes and frequently of undesirable nutritional value.

The main aim of the current review was to investigate whether changes in diet and obesity have taken place over the past 33 years in Sub-Saharan African countries and whether there is a rising incidence of NCDs accompanying such changes (see Text Box 1).

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Box 1. Search strategy

In writing this review, we accessed peer reviewed articles, reports, reviews, and chapters that presented data on obesity and its nutrition-related determinants in different Sub-Saharan African countries between January 1980 and October 2013 from Pubmed/Medline, EBSCOhost Web, Proquest Nursing and Allied Health Source, Proquest Health, ScienceDirect, Medical Complete, and Cochrane using the key words "obesity" and "SSA," and "nutrition transition" and/or "NCDs" and/or "diet" and/or "nutrition." For comparison purposes, data on obesity and nutrition-related determinants that represented different countries in SSA around the same time line (1980–2013) from the World Health Organization Global InfoBase,[5] Food and Agriculture Organization Statsfile,[6] World Bank,[7] and Demographic and Health Surveys (DHSs)[8] were also used. The time frame of 1980 to October 2013 was selected because it was reasonable enough to show shifts in nutrition-related determinants of populations. All publications falling within this time period that included data on dietary intake and/or obesity and/or NCDs in any Sub-Saharan African country were included.

Nutrition transition

The *nutrition transition* is a descriptive term for shifts in dietary patterns, usually at the community or population level. It can be visualized as a shift from periods of famine, to those of receding famine, to those of nutrition-related chronic diseases of lifestyle resulting from increased affluence.[9,10] Changes in diet are toward less unrefined foods and carbohydrates, accompanied by an increase in animal protein, saturated fat, and sugar. This lifestyle pattern is also associated with lower energy expenditure.

A demographic transition is said to occur when a country experiences improved socioeconomic development resulting in improved lifestyle and health status. It is further accompanied by an epidemiological transition that exhibits as a change in disease profile from that of infectious diseases to a pattern of chronic degenerative diseases. The nutrition transition accompanies these demographic and epidemiologic shifts toward nutrition-related NCDs, including diabetes, CVD, osteoporosis, and certain cancers.[11] According to the World Health Organization (WHO),[12] the effects of the nutrition transition are further exacerbated by decreased physical activity, stressful lifestyle, high alcohol consumption, and tobacco use.

Benjamin Caballero, in Mattei *et al.*,[13] described the main drivers of the epidemiological transition as being increased life expectancy, urbanization, increased household income, resulting from economic growth, globalization affecting food production and marketing, and unhealthy lifestyle characterized by poor diet and physical inactivity.

The concept of nutrition transition was first described by Popkin[14] and later expanded by Drewnowski and Popkin.[15] On the basis of analyses of global diets, they proposed that the availability of cheap vegetable oils and other fats (including from milk and meat) has resulted in increased fat consumption in low-income nations. Nutrition transition, according to Popkin,[12] is fueled by urbanization, increased access to supermarkets, and a decrease in food prices. Caballero in Mattei[13] also emphasizes the increased accessibility of multinational low-priced food chains, the increase in street food vendors selling energy dense processed foods in poor areas, and the increased consumption of sugar-sweetened beverages as being powerful forces in changing dietary patterns.

The nutrition transition has been eloquently defined by Luke *et al.*,[16] who described the nutritional consequences of the African diaspora. They regard West Africans as being in the early stages of transition on the basis of their (still) relatively low intake of fat and processed foods. Undernutrition was still common, and the prevalence of obesity was still low before 2001. The Caribbean diet at the time was regarded as falling within the middle phases of the nutrition transition, since fat intake was higher (25–30% of energy intake) and undernutrition levels in children had decreased. By contrast, black Africans living in the United Kingdom and United States are in the last stages of the nutrition transition, whereby undernutrition and deficiency diseases have shifted to diseases of excess, as illustrated by a high prevalence of overweight and obesity.

Vorster and Bourne[17] have described the changes taking place during this transition as being about

food availability and cost of food resulting in certain food behaviors that govern the intake of certain nutrients and energy intake, in turn leading to an adverse nutritional status that may lead to morbidity and mortality on the basis of food choices made. The nutrition transition results in people selecting a more Western diet above the typical traditional diet eaten by the population over many generations. There are frequently marked differences between eating patterns in urban and rural areas, with urban areas adopting a more Westernized diet owing to a greater availability of such foods in urban areas.[17]

The nutrition transition is further governed by political, technological, and political factors. These include globalization, governance, and the impact of the food industry.[11,18] Governance at the country level is of vital importance since it determines the food and nutrition policy of the country, as well as levels of poverty and food security of the population. Sub-Saharan African countries on the whole have been particularly affected since poor governance in many has resulted in widespread poverty and poor food security. However, despite periodic episodes of famine in many Sub-Saharan African countries there have also been major dietary changes resulting from globalization, including heavy marketing from the food industry and more flexible trade policies. At the household level, people with more disposable income and increasing levels of education have tended to adopt new dietary patterns, particularly when trade policies have made convenience foods available and prolific.[11,18]

Raschke and colleagues[19] proposed that the nutrition transition in East Africa has been taking place over the past 400 years since the period of colonial occupation. The latter resulted in the distortion and extinction of indigenous and traditional food habits in East Africa resulting in the creation of NCD epidemics throughout the region. Marabou[20] describes outcomes of the nutrition transition as having occurred largely because of changes taking place during World War II when the food supply was scarce in Europe. This led to a revolution in government thinking and a cheap food policy with an intense promotion of meat, milk, butter, and sugar production and consumption. However, the resulting increase in degenerative diseases slowly changed public health policy.

According to Popkin[21] the nutrition transition is now occurring at greater speed and at earlier stages in low- and middle-income countries. This is ascribed to different forces, including influences faced by low- and middle-income societies today compared with those faced by higher income industrialized society's decades ago. It has, for example, been reported that more than half of the countries in SSA are still in the early stage of the nutrition transition, while a few have already reached a position where changes in dietary patterns are affecting health outcomes in a significant proportion of the population.[22] Differences in rates of change may also be influenced by issues related to body composition and potential genetic factors.[21]

Another typical feature of the nutrition transition is the coexistence of both maternal overweight and child malnutrition in the same household or community.[23,24] This is illustrated in Figure 1, which shows that many countries in SSA have both a high prevalence of stunting in children and of overweight and obesity in mothers. Stunted children may become stunted adults, who in turn appear to be more at risk of developing chronic NCDs in later life.[25] A study in Benin, for example, showed that child protein energy malnutrition coexisted with maternal overweight/obesity in 16.2% of 148 households in poor neighborhoods. The authors theorized that child malnutrition and maternal overweight could both stem from poor socioeconomic conditions, lack of sanitation, and poor dietary variety.[23]

Consequences of the nutrition transition

From a biological perspective there is convincing evidence that moving from a traditional diet high in carbohydrate and fiber and low in fat and sugar to a Westernized diet high in energy, saturated fat, sodium, and sugar and low in fiber, increases the risk of obesity, hypertension, stroke, type 2 diabetes, ischaemic heart disease (IHD), and certain cancers.[10] Over the past 20 years the prevalence of type 2 diabetes and CVD have increased 10-fold in SSA.[26]

According to the WHO, NCD deaths are projected to increase by 15% globally between 2010 and 2030, with most increases taking place in the Africa, South-East Asia, and Eastern Mediterranean regions where they are expected to increase by more than 20%.[1] In 2008, age-standardized NCD mortality rates were highest in the Africa region for females (724 per 100,000) and males (844 per 100,000). Behavioral risk factors, such as poor diet, physical inactivity, and tobacco use, were responsible for about

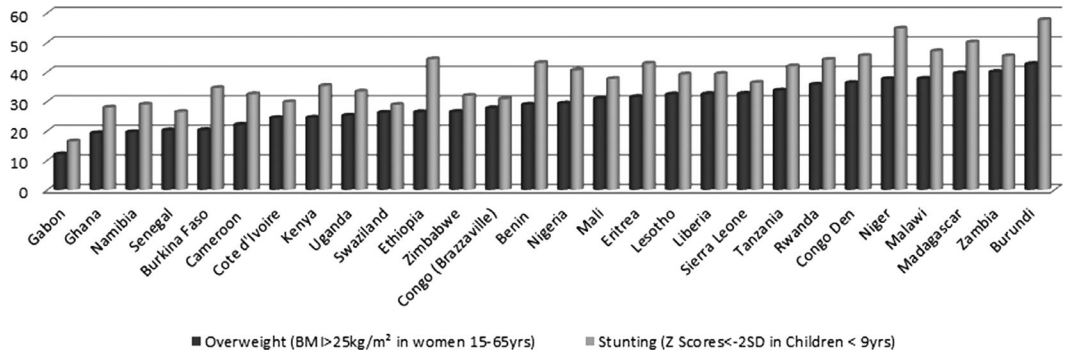

Figure 1. The double burden of malnutrition showing overweight and obesity (BMI $\geq$ 25) in mothers and stunting in children (weight for age $<$ $-$2 SD) by Sub-Saharan African country. From Ref. 8.

80% of cerebrovascular disease and coronary heart disease.[1]

One of the most serious and problematic outcomes of the nutrition transition has been the increased level of obesity globally.[27,28] Since obesity is a risk factor for most of the NCDs, it is understandable that these have increased correspondingly. In SSA, obesity levels are still lower than in high-income countries but certainly higher than they were two decades ago. Obesity has rapidly become a problem of the poor. For example, according to Echouffo *et al.*[29] the prevalence of overweight and obesity increased in urban areas of Cameroon between 1994 and 2003 from 54% to 82%. Associated with this, a two- to fivefold increase in hypertension and a 10-fold increase in diabetes were found, which the authors ascribe to unfavorable eating habits, physical inactivity, and an increase in tobacco use.

Overweight and obesity in SSA

The double burden of malnutrition is illustrated in Figure 1 developed from DHSs.[8] Countries such as Burundi and Madagascar have prevalence rates of overweight and obesity around 40% and rates of stunting over 50%. At the lower end of the scale, levels of overweight and stunting are also closely matched. Rates of stunting are over 40% in seven countries: Zambia, Namibia, Congo, Malawi, Madagascar, Niger, and Burundi. Both gross domestic product (GDP) and prevalence of overweight show an increase from 2002 to 2010 (Fig. 2). In this figure it is important to note that the data from the World Bank[7] and the WHO Global Infobase[5] show that GDP and overweight rates are closely associated. This is illustrated by, for example, Ghana, Swaziland, Cape Verde, Botswana, South Africa, and Seychelles, with both GDP and overweight statistics being high. The prevalence of overweight is very high (over 50%) in South Africa and Seychelles.

Available energy, protein, fat, sugar, and fruits and vegetables in Sub-Saharan African countries: 1980–2009

Figure 3 provides per capita energy supply from 1980 to 2009 available from the Food and Agriculture Organization (FAO) food balance sheets.[6] We used this time line because the nutrition transition can be demonstrated successfully over a period of three decades (1980 to today). For instance, evidence suggests that urbanization on the African continent began around 1975 where a massive growth of industries, especially emerging manufacturing in the urban areas of Africa began.[3,4] This was then followed by a massive growth of fast food franchises, especially those that sell energy-dense food (high in added sugar and high in fat). FAO food balance sheets were our preferred source of information since they provided data on availability of food per capita. This does not imply that the food is equally distributed among people. It does, however, indicate overall how much is available and whether it is increasing or decreasing over time. In 2009, only three countries had a per capita supply less than 2000 kcal: Burundi, Eritrea, and Zambia. Fifteen countries had an available energy supply greater than 2500 kcal in 2009, many of these coming from positions of having less than 1800 kcal in 1980, namely Benin, Mali, Gambia, Burkina Faso, Nigeria, and Ghana. A small number of countries had a decreased available energy supply since 1980, including Burundi, Zambia, Kenya, Madagascar, Namibia, Central African Republic, Rwanda, Zimbabwe,

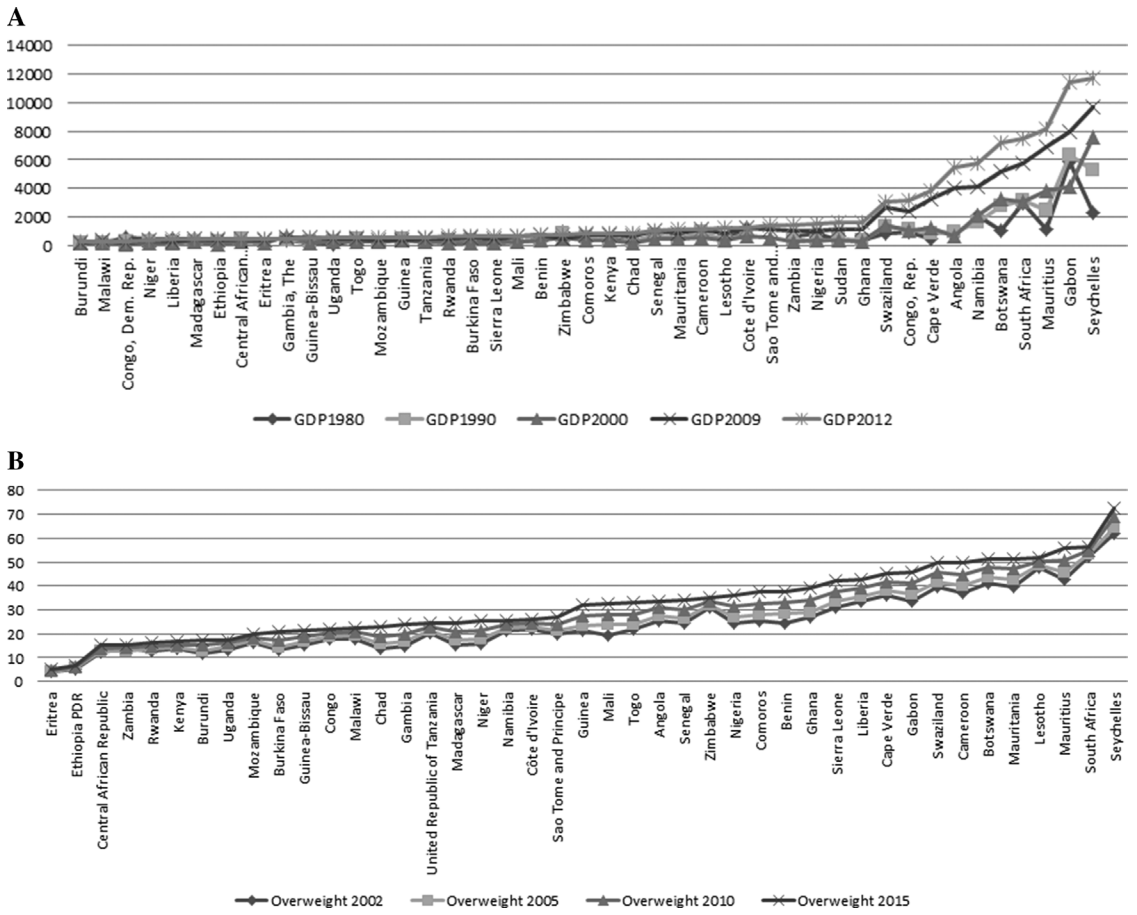

Figure 2. (A) Sub-Saharan African countries by GDP and (B) overweight (BMI ≥ 25–29.9). From Refs. 5 and 7.

Swaziland, Liberia, and Cote d'Ivoire. Overall, however, the general picture indicates a steady increase in the available energy supply in most Sub-Saharan African countries, which has contributed to the increase in obesity.

Per capita available protein and fat intakes are presented in Figure 4 and illustrate a similar picture to that of energy supply available. For the majority of countries the total available protein supply in 2009 has been above 50 g/person/day, rising to above 70 g in 10 countries: Sudan, Mali, Cape Verde, Seychelles, Burkina Faso, Niger, Gabon, South Africa, Mauritania, and Mauritius. A few countries have, however, experienced a reduction in protein availability since 1980, including Liberia, Burundi, Zambia, Madagascar, Cote d'Ivoire, Zimbabwe, Kenya, Namibia, Senegal, Malawi, and Lesotho. In Burundi, Eritrea, Madagascar, and Rwanda per capita fat supply is less than 20 g/person/day, rising to more than 70 g in Senegal, Central Africa Republic, Sao Tome, Cape Verde, Mauritius, Mauritania, and South Africa. With the exception of Madagascar, Cameroon, Sierre Leone, and Sudan, all countries have experienced an increase in available fat supply between 1980 and 2009, which has contributed to the nutrition transition taking place. An increase in fat consumption is highly associated with dietary changes and the nutrition transition.

Available sugar intake varies considerably between the four time periods (1980, 1990, 2000, and 2009), ranging from virtually nothing to nearly 120 g per capita/person/day (Fig. 5). It does appear as if countries having the highest intakes have a decrease in availability of sugar supply since 1980 and/or 1990. Of note is the finding that 17 countries have a per capita supply of more than 40 g per day, which is recommended as the maximum recommended for health.[30,31] This would certainly

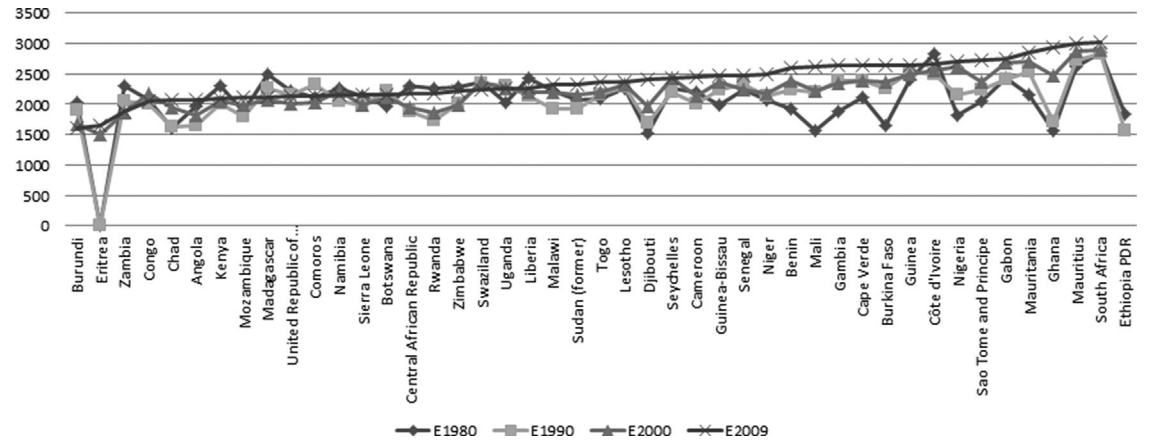

Figure 3. Per capita energy available for each Sub-Saharan African country between 1980 and 2009. From Ref. 6.

contribute to the emerging nutrition transition, since a high sugar intake is associated with the changing of lifestyle from a traditional diet to a more Western one, with a high consumption of sugar-sweetened beverages being one such adoption. Recent evidence has shown that sugar-sweetened beverages are associated with obesity, diabetes, and cardiovascular diseases.[32,33]

Basu *et al.*[34] used multivariate linear regression to estimate the association between soft drink (sugar-sweetened) consumption and overweight, obesity, and diabetes prevalence in 75 countries (including in SSA). They found that every 1% rise in soft drink consumption was associated with an additional 4.8 overweight adults per 100; 2.3 obese adults per 100, and 0.3 adults with diabetes per 100. The finding remained robust in low- and middle-income countries.

The consumption of fruits and vegetables varied considerably in the Sub-Saharan African countries over the past 30 years (Fig. 5). It has decreased considerably in a few countries, namely Angola, Madagascar, Botswana, Swaziland, Cote d'Ivoire, Guinea, Uganda, Gabon, and Rwanda, and increased in Ghana, Sudan, Mauritius, Cape Verde, Seychelles, Cameroon, and Sao Tome.

Figure 6 illustrates the fact that intake of carbohydrates are still very high in Sub-Saharan African countries, being over 60% and even close to 80% in some countries. Available fat intake is less than 30% of energy intake in all Sub-Saharan African countries. This implies that despite the fact that the nutrition transition is taking place, it has not yet reached the undesirable level of 30% or higher, as indicated by the WHO.[8] Protein intake still lies around 10% to 15% of energy, which further supports the notion of Sub-Saharan African countries being in a state of early transition.

Studies on changing diet associated with the nutrition transition

As mentioned earlier, the nutrition transition is characterized by increased intakes of saturated fat, animal protein, and sugar, and decreased intake of carbohydrate and fiber, as people change from a traditional diet to a more Westernized one. The following studies in SSA support this to varying degrees.

Two studies in South Africa have illustrated the outcomes of the nutrition transition. Bourne *et al.*[35] examined dietary intake of black adults ($N = 649$) residing in Cape Town. Certain trends were observed with increased time lived in the city (having moved from rural areas). Carbohydrate intake decreased from 61.4% of energy intake to 52.8% of energy intake, while fat intake increased from 23.8% to 31.8% over time spent in the city. Fiber intake decreased from 20.7 to 16.7 grams.

In another study evaluating changes in dietary intake, the diets of black Africans ($n = 743$) were examined in urban and rural settings of differing socioeconomic status (SES) in the northern areas of South Africa.[36] The urban upper-income group had the highest fat (30.6% of energy intake), cholesterol (420 mg), and protein (13.3% of energy intake) intake, while rural residents and rural farm workers were found to follow a very prudent diet

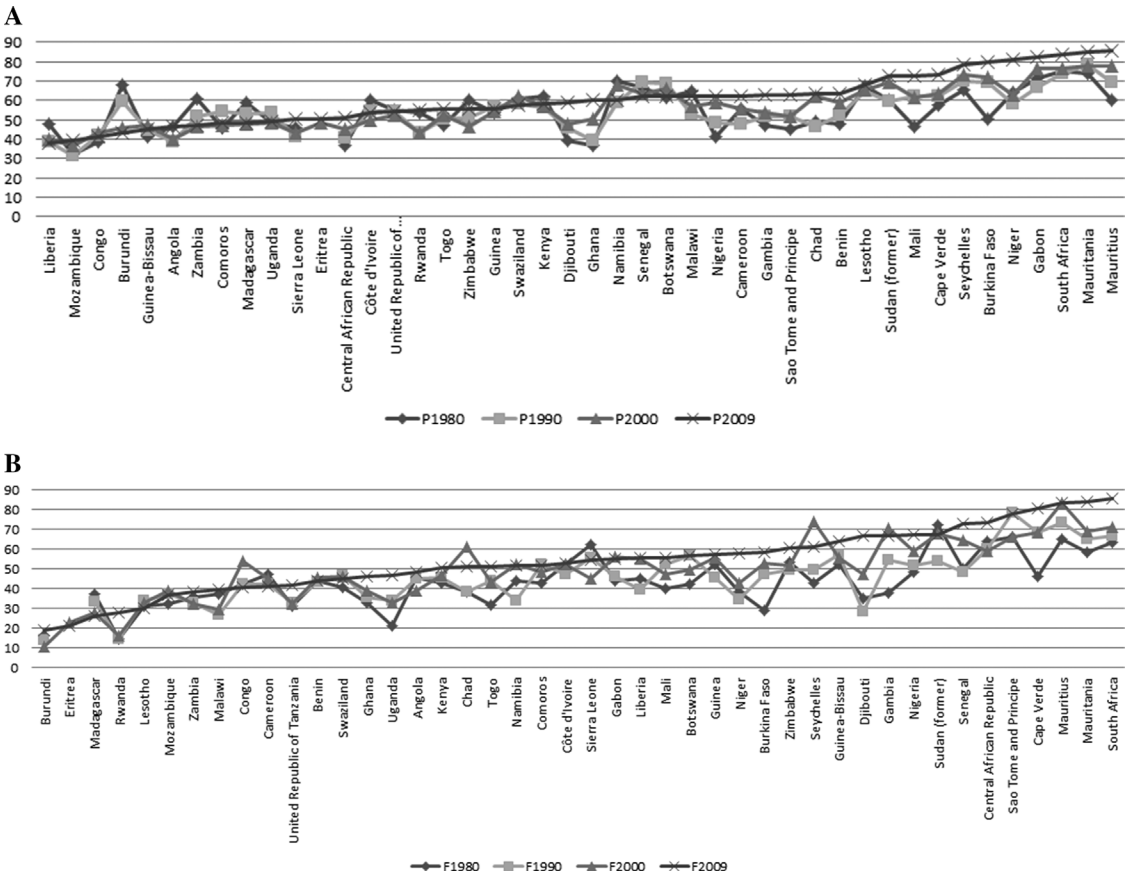

Figure 4. Per capita protein (P) and fat (F) available per Sub-Saharan African country between 1980 and 2009. From Ref. 6.

significantly lower in fat (22.8%), protein (12.1%), and cholesterol (283 mg) and higher in carbohydrate (67.2%).

Sodjinou *et al.*[37] examined the diet of urban Beninese adults ($n = 200$). They found two types of dietary patterns, namely traditional and transitional. The transitional diet had a higher percent energy from fat, saturated fat, and sugar. It was significantly lower in fiber and higher in cholesterol than the traditional diet. The traditional diet was also found to be healthier (on the healthfulness score) and more varied with regard to dietary diversity.

Amare and colleagues[38] studied the diet of urban Ethiopian adults ($n = 356$). They found that 12.9% were underweight, 21.3% were overweight, and 5.9% were obese. Fish, fruit, and vegetables were infrequently consumed, while butter and oil were consumed daily by most participants. Protein intake was inadequate in 11.2% of adults, while calcium, retinol, thiamin, riboflavin, niacin, and vitamin C were inadequate in more than 70% of participants. Their study illustrated the regular intake of fats at the expense of fruits and vegetables, resulting in a deficiency of micronutrients.

Rural to urban migration was studied in 132 adults in Tanzania, before and 12 months after migration.[39] At 12 months, weight increased (2.30 kg in men, 2.35 kg in women, $P < 0.001$) and vigorous physical activity declined (79.4% to 26.5% in men, 37.8% to 15.6% in women, $P < 0.001$). Intake of fresh fruits and vegetables was found to increase, as did intake of red meat, the latter being a typical outcome of urbanization. High-density lipoprotein cholesterol (HDL-C) increased in both men and women (0.24, 0.25 mmol/l, respectively, $P < 0.001$), while triglycerides fell (0.31 mmol/l, $P = 0.034$).[36–39]

A dietary survey was conducted on 1008 women in a nationally representative sample in Kenya to examine urban–rural differences in diet.[40]

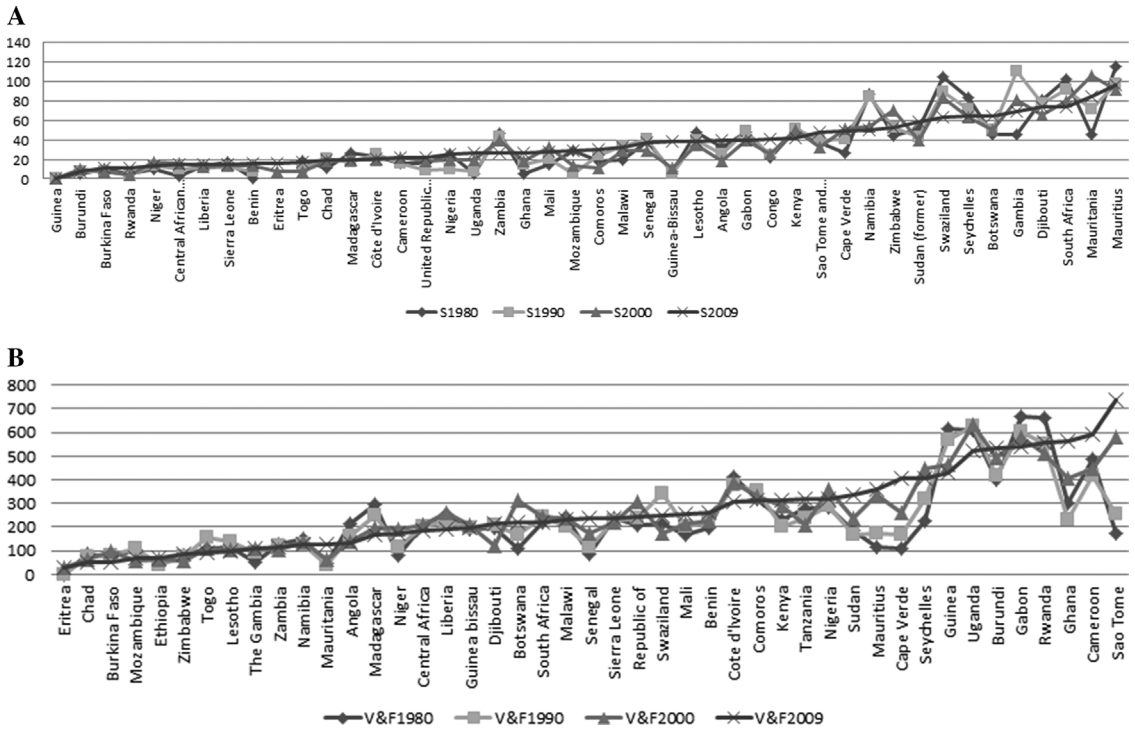

Figure 5. Available supply of sugar (S) and fruits and vegetables (FAV) per capita in Sub-Saharan African countries between 1980 and 2009. From Ref. 6.

Overall, overweight and obesity (BMI $\geq$ 25) was found to be 43.3%. Obesity was most prevalent in urban women and in the high SES group. Women in the high SES group (7278 kJ) and in urban areas (7049 kJ) had the highest mean energy intake. There were significant urban/rural differences in the contribution of macronutrients to total energy intake. Total fat intake was 34.5% of energy intake in urban areas and 29.7% energy intake in rural areas, while carbohydrates contributed 69.9% to energy intake in rural areas and 57.4% to energy intake in urban areas ($P < 0.0001$). This study also illustrated nutrition transition stages between urban and rural areas.

Deslile *et al.*[41] examined the effect of the urban–rural gradient and SES on cardiometabolic risk markers in adults ($n = 541$). They found the most advanced stage of the nutrition transition to be associated with poor diet quality and lower physical activity in the city compared with the transition taking place in more rural areas. Income, urbanization, alcohol consumption, and sedentary lifestyle independently contributed to higher BMI and waist circumference (WC).

A summary on studies undertaken on the urban–rural transition of diet in SSA has shown that, generally, the urban diet is unhealthier than the rural, more traditional one. Intakes of fat, sugar, and red meat are higher in urban areas, while people residing in rural areas consume more carbohydrates and fiber, and less protein and fat.

Causes and predictors of obesity

In the Sub-Saharan African context, certain common and unique predictors of obesity have been identified and are illustrated by the following studies. A study on urban adults in Cameroon ($n = 771$) showed that occupation, ethnicity, increasing level of education and physical inactivity appeared to be significant predictors of overweight.[42] Steyn *et al.*[40] found that overweight and obesity in Kenyan women ($n = 1008$) were significantly more likely in the highest SES group—in households having a low room density, electricity or gas available for cooking, and households with their own tap and/or own flush toilet. They concluded that urbanization and the associated economic advancements are among

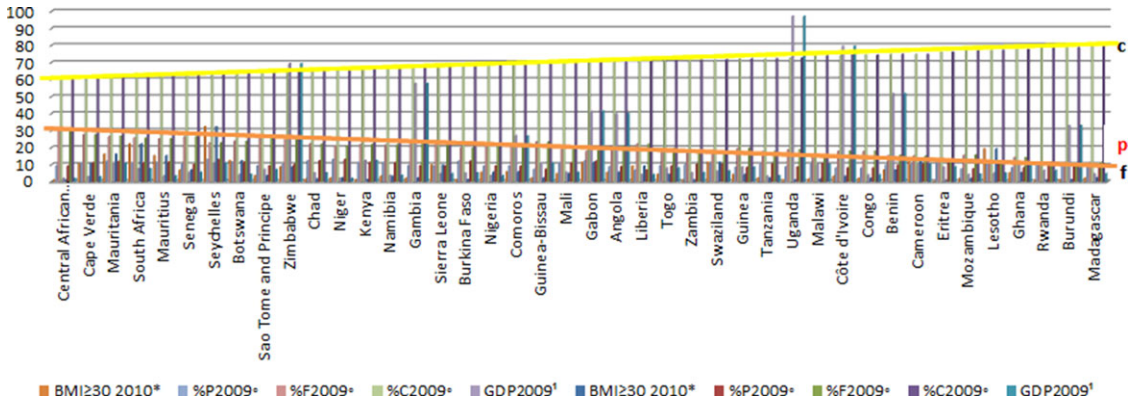

Figure 6. A comparison of GDP, obesity (BMI > 30), fat (F)% of energy, protein (F)% of energy, and carbohydrate (C)% of energy. From Refs. 5–7.

the most important determinants of overweight and obesity in Kenyan women.

Results from another study on women in Nairobi ($n = 365$)[43] found that age was the most significant predictor of all the independent variables. Parity was a significant predictor of BMI and WC. Certain dietary variables were also predictors of BMI. The lower SES group had higher mean fiber ($P < 0.001$) and carbohydrate ($P < 0.05$) intakes, while the high SES group had higher protein ($P < 0.05$), cholesterol ($P < 0.05$), and alcohol ($P < 0.001$) intakes. Those having a fat intake greater than the 100% recommended dietary intake had a significantly greater BMI than those with an intake less than recommended dietary intake ($P < 0.05$). The researchers indicated that these women were well into the nutrition transition since they had a diet high in energy, protein, fat, cholesterol, and alcohol, and moreover had a sedentary lifestyle.

A study comparing women in Kenya ($n = 1008$) and South Africa ($n = 4481$) noted that the nutrition transition was similar in both countries despite large socioeconomic differences.[44] In both countries there were large urban–rural differences in BMI, with the highest prevalence of overweight and obesity being in urban areas. BMI and waist hip ratio was found to increase with age and was greater than 45% in older women in both countries.

Delisle *et al.*[45] examined the prevalence of obesity in adults at three field sites: one in Benin ($n = 540$) and two in Burkino Faso ($n = 650$). Obesity was found to be higher in affluent city dwellers but not hypertension, insulin resistance, or dyslipidemia. Abdominal obesity was very high in women (48%) but not in men (6%). Protective factors against chronic diseases were physical activity and adequate micronutrient intake. In a study in Benin adults ($n = 541$), both underweight (11.3%) and overweight/obesity (35.3%) were found, and low HDL-C was observed in more than 25% of adults.[46] The rate of low HDL-C was highest (41.9%) among the overweight/obese subjects, but it also reached 31.1% among underweight participants, suggesting that low HDL-C may be associated with either overweight or underweight.

Dake and colleagues[47] also studied in effect of SES on BMI in women subjects from the 2003 and 2008 Ghana DHSs, in which prevalence of obesity and overweight increased from 25.5% to 30.5% between 2003 and 2008. They found that obesity prevalence was highest in older women in urban areas who were married and from affluent households. Benkeser *et al.*[48] examined 2814 Ghanaian women to determine associated risk factors for obesity. They found that 37.1% women were obese, 27.8% were overweight, and 3.6% were underweight. Age, relative wealth, being married, having grown up in an urban environment, and having parity greater than 2 were associated with a higher risk of overweight or obesity.

Predictors of overweight were assessed in 1818 adults residing in Maiduguri, Nigeria.[49] After adjusting for confounders, overweight was found to be associated with the following variables: poor neighborhood aesthetics; unsafe conditions from traffic; distant access to commercial facilities; perceiving garbage and offensive odors in the neighborhood; and feeling unsafe from crime at night. Predictors of

overweight were also studied in Eastern Uganda in adults.[50] The overall prevalence of overweight was found to be 18% (25.2% of women; 9.7% of men; $P < 0.001$), while prevalence of obesity was 5.3% (8.3% of women; 2.2% of men). Variables associated with being overweight included being female, living in a peri-urban area, having higher SES, and increasing age. Protective factors against overweight were meeting the recommended minimum physical activity level and having a moderate dietary diversity score. Being overweight in low-income settings was associated with sex, physical activity, and dietary diversity.

Desirable body weight size appears to differ in African women. A study undertaken on adult women ($N = 301$) in Dakar, Senegal found that 45.2% were overweight or obese in 2004 compared with 30.4% in 1996.[51] Overweight was seen as the most socially desirable body size while obesity was associated with greed, heart disease, and diabetes. About a third of women saw the overweight category as being "normal." A study conducted in adolescents in Nigeria ($n = 910$) found that 6.4% were underweight, 6.3% were overweight, 1.8% obese, and 5.4% were stunted.[52] Factors more common in overweight children were high SES, higher maternal education, spending more than 3 h a day watching television, and frequent ingestion of snacks.

A cross-sectional study of 1599 children and adolescents 5 to 18 years was undertaken in Lagos, Port Harcourt, Nsukka, and Aba in Nigeria.[53] The prevalence of thinness, overweight, and obesity were 13.0%, 11.4%, and 2.8%, respectively. More females (3.7%) than males (1.8%) were obese ($P < 0.05$). The prevalence of overweight was highest (23.1%) at age 15 years; the prevalence of thinness was highest (28.6%) at age 7 years. The rates of overweight, obesity, and thinness were affected by location and income levels. Wrotniak *et al.*[54] examined obesity in 707 adolescents in two different SES categories in Botswana. They found that private school students and those with more assets had a higher prevalence of overweight and obesity (27.1%) compared with public school students (13.1%).

In summary, a number of factors appear to be predictors of overweight and obesity. These include being female, of older age, parity greater than two, urban residence, high SES category, and spending more than 3 h a day watching television. Protective factors include increased physical activity, greater dietary diversity, and adequate micronutrient intake.

The double burden of malnutrition

A number of studies in SSA have examined the double burden of malnutrition on the basis of the fact that both pediatric obesity and short stature in adults are risk factors for the metabolic syndrome and metabolic diseases in adults.[55] Sawaya *et al.*[56] conducted a review on the double burden and proposed a model to explain how early malnutrition alters energy balance in adults. They showed the coexistence of malnutrition and obesity in households in slums in Brazil with a high prevalence (30%) of stunting and overweight/obesity in the same household. They postulated that owing to an energy deficit, a higher cortisol: insulin ratio associated with a lower level of IGF-1 leads to lower linear growth and muscle gain, fat oxidation, and impaired lypolysis. When such hormonal changes are associated with a higher fat or carbohydrate diet and/or a decrease in physical activity, obesity with short stature occurs. It also appears that stunted children showed a greater susceptibility to a high fat diet, have lower fat oxidation, and higher fat gain.

Popkin and colleagues[57] evaluated the risk of obesity in stunted children in four countries, Russia, Brazil, China, and South Africa. Their results showed that there was a significant association between stunting and overweight in children (3–9 years) in all the countries, with the income-adjusted risk ratios of being overweight for a stunted child ranging from 1.7 to 7.8. Regarding the double burden, significant predictors of overweight and obesity found in a rural group of adolescents ($n = 4000$) in South Africa were child's age, gender, household level food security, head of household level of education, and SES. Early stunting was associated with adolescent obesity.[55]

Zeba *et al.*[58] described the double burden in Burkina Faso. They found that at least one nutritional deficiency and one CVD risk factor were observed in 23.5% of adults studied. This condition was found to be significantly higher in women than in men and in the lowest SES group. Pawloski *et al.*[59] studied spatial clustering of weight status of mothers and their children in various regions of Kenya. In Nairobi, an urban area, there was a predominance of overweight mothers and overweight children, while in rural areas there were clusters of underweight

mothers and children. In Kisumu (rural) there were clusters of overweight children with normal weight mothers and in Mombasa clusters of overweight mothers with normal weight children. The authors concluded that there are some defined patterns concerning the distribution of malnutrition in mothers and children, and they recommend the need for further study in this regard.

Obesity in cardiovascular studies

IHD still remains relatively uncommon in SSA; however, its prevalence is predicted to rise in the next two decades because of the rising prevalence of risk factors, especially overweight and obesity, hypertension, diabetes, physical inactivity, increased tobacco use, and dyslipidaemia.[60] According to Onen, age-standardized mortality rates for IHD will rise by 25% in African women and by 27% in African men by 2015, and by 74% and 70%, respectively, by 2030. Studies that have examined overweight and cardiovascular diseases and diabetes in SSA are presented here.

Cardiometabolic risk factors were examined in apparently healthy adults in Benin ($N = 541$).[46] Low HDL-C was observed in more than 25% of participants. Both overweight/obesity (35.3%) and underweight (11.3%) were present, displaying the double burden of malnutrition. Dietary quality was determined using two 24 h recalls. Low HDL-C was associated with more abdominal obesity in men and women and with more insulin resistance in women. The rate of low HDL-C was highest (41.9%) among the overweight and obese subjects (BMI $\geq$ 25), compared with 17.3% among normal-weight adults ($P < 0.001$), and 31.1% among the underweight adults (BMI $<$ 18.5). Lower dietary nutrient adequacy (particularly vitamins A, B3, B12, zinc, and calcium) was associated with low HDL-C. It was concluded that at-risk lipoprotein cholesterol may be associated with either underweight or overweight/obesity and with poor micronutrient intake.

A cross-sectional study of public-sector workers ($n = 615$) at Agostinho Neto University in Angola from various socioeconomic groups was undertaken to determine risk factors for NCDs.[61] The following prevalence rates were recorded: smoking 10.2% in men and 4.4% in women, $P < 0.05$; diabetes, 5.5% in men and 5.9% in women, $P > 0.05$; overweight, 27.3% in men and 31.2% in women, $P > 0.05$; obesity 9.2% in men and 29.0% in women, $P < 0.05$; sedentary lifestyle, 83.0% in men and 91.0% in women, $P < 0.05$. Furthermore, 45.2% of the sample had hypertension, 11% had hypercholesterolemia, 50.1% had low HDL-C, and 10.6% had hypertriglyceridemia. Fifteen percent of the participants had two risk factors, and 31.4% had three or more risk factors. Among the individuals with low SES, 41.0% had three or more risk factors. This study demonstrated very high levels of CVD risk factors in an African population.

Multimorbidity, as illustrated by the previous study, has also been determined in a national South African study.[62] Multimorbidity is defined as the coexistence of two or more chronic diseases in an individual. The overall prevalence of multimorbidity in South Africa was 4% in the adult population. Factors associated with multimorbidity were obesity, depression, health facility visits, social assistance, and smoking. Moreover, income was strongly positively associated with multimorbidity.

Okpecki *et al.*[63] determined CVD risk factors in 2983 subjects in Abia State Nigeria. Prevalence rates for risk factors were being overweight or obese (33.7%), hypertension (31.4%), diabetes (3.6%), cigarette smoking (13.3%), and physical inactivity (64.2%). Low income, lack of any formal education, and use of smokeless tobacco were seen more frequently in rural dwellers than in those living in urban areas ($P < 0.05$). The frequency of selected CVD risk factors increased as blood pressure increased, and high blood pressure correlated with gender, age, overweight or obesity, smokeless tobacco, annual income, and level of education.

A cross-sectional descriptive study of 400 adults was undertaken in Ogbomoso, Nigeria.[64] The prevalence of obesity was 8.9% for males and 19.5% for females ($P < 0.05$), with females being significantly more sedentary than the males (50.8% for males, 62.4% for females, $P < 0.05$). The overall prevalence of abnormal lipid levels was 28.5%, while the prevalence of abnormal lipid levels among the subjects who were obese was 40.7%. It was concluded that obesity was particularly significant among females and furthermore was associated with abnormal lipid levels.

Muhihi *et al.* examined CVD risk factors among men aged 20–50 years ($n = 97$) in urban Mwanza, Tanzania.[65] With the exception of hypertension (23.7%), the prevalence of CVD risk factors were low. One of the main reasons for this was attributed

to high physical activity energy expenditure and inversely related to WH ratio, systolic BP, heart rate, total cholesterol, LDL cholesterol, triglycerides, and fasting blood glucose.

A Steps Study was carried out in Lome, Togo in 2000 subjects 18 years and older.[66] This study found the prevalence of risk factors for CVD and diabetes to be very high. Hypertension was prevalent in 26.6%; stress in 43%; sedentary lifestyle in 41%; hypercholesterolemia in 26%; obesity in 25.2%; hypertriglyceridemia in 21%; smoking in 9.3%; alcohol use in 11%; and diabetes in 7.3%.

The increase in obesity and associated risk factors for CVD is thought to be the result of metabolic imprinting. The latter is the result of intrauterine and infant malnutrition.[67] Waterland and Garza[68] defined the term *metabolic imprinting* as being the basic biological phenomena that underlie the relationship between nutritional experiences in early life and later diseases. They describe four conditions that are closely associated with this process: a critical window period when the fetus is most susceptible to nutritional experiences; a lasting effect throughout adulthood; a measurable outcome; and a dose-response relationship between exposure and outcome.

In summary, the former studies have illustrated that obesity and CVDs are closely associated morbidities in numerous Sub-Saharan African studies, including Benin, Angola, RSA, Nigeria, Tanzania, and Togo. Symptoms include hyperlipidemia and hypertension, while determinants of CVD include a high prevalence of obesity, nicotine use, high alcohol consumption, and inactivity.

Summary

Countries in SSA are still in the early stages of the nutrition transition, as illustrated by the finding that available fat, protein, and carbohydrate levels are still within those levels recommended for a prudent diet. However, it needs to be acknowledged that GDP levels and prevalence of overweight and obesity are rising, in addition to per capita available energy, fat, protein, and sugar. Within the next few years it is likely that dietary changes (accompanied by high levels of inactivity) will shift toward those associated with the development of NCDs. This emphasizes the importance of early public health interventions to prevent the transition from reaching critical levels.

Conflicts of interest

The authors declare no conflicts of interest.

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