Nutrition and oral health in Africa

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Poverty, low birth weight, low life expectation at birth, widespread malnutrition, numerous endemic infections, little or no access to safe water, poor oral hygiene, deplorable environmental sanitation and political instability among other problems, characterise the lives of many Africans, particularly in sub-Saharan Africa. In African countries undergoing rapid urbanisation, health problems associated with undernutrition and overnutrition coexist, and these result from lifestyle changes which promote physical inactivity, increased consumption of fats and refined carbohydrates, as well as abuse of tobacco and alcohol. Thus, in several African countries, inflammatory oral diseases (e.g. periodontal diseases, acute necrotising gingivitis, noma) resulting from inappropriate interactions between microorganisms and the malnourished, immunocompromised host, have continued to pose serious health problems. There are suggestions of increasing incidence of squamous cell carcinoma, probably related to increased use of alcohol and tobacco, which elicit nutrient deficiencies and oxidative stress. Additionally, there is an increase in caries prevalence particularly in the poor urban areas. The latter is related not only to increased availability of refined sugars, but also to limited access to the caries preventive effects of fluorides. Good dietary practices through judicious combination of available foods should therefore feature prominently in the promotion of optimal oral health in Africa.

Key words: Nutrition, undernutrition, inflammatory diseases, Africa

Africa, the second largest continent in the world, occupies about 25% of the world’s landmass, and contains 54 member States of the World Health Organisation. Thirty-three of these States belong to the World’s 47 least developed countries. The total population of Africa was estimated to be 750 million in 2000, and made up of various ethnic/racial groupings. The northern part of the continent is inhabited mainly by people of Arab descent, while a large number of different indigenous groups reside in sub-Saharan Africa. The continent also contains a large number of people of Indian and European descent. Africa constitutes a world of bewildering contradictions in which the majority residing in the rural areas and the poor urban towns lack the basic essentials of life, while the very few affluent, many of whom are educated in the best traditions of the Western World, often engage in gluttonous lifestyles. It is estimated that 24% of sub-Saharan Africans live on less than US $1.00 daily, compared to 0.5% in the Middle East and Northern Africa, and 43.5% in Southeast Asia. For the vast majority of Africans, life is characterised by extreme poverty, low life expectation at birth, inadequate education, and little or no access to safe water and quality health care services. The percentage of the population with access to safe water and adequate sanitation varies from about 4% in...
sub-Saharan Africa to 80% in the Middle East and North Africa\(^\text{1,5}\). Infant mortality rate (per 1,000 live births) in 1998 was 110 for sub-Saharan Africa and less than 50 for Middle East/North Africa. Children less than 5 years of age constitute about 20% of the total population of sub-Saharan Africa, but account for 60% of all deaths\(^\text{5,4}\). Widespread protein-energy malnutrition (PEM), often complicated by concurrent, multiple micronutrient deficiencies and several endemic communicable diseases (e.g., malaria, measles, acute respiratory infections, diarrhoea, tuberculosis, and others), underlies the high infant and childhood mortality rates observed in the sub-Saharan region\(^\text{1}\). The latter is further compounded by the pandemic of HIV/AIDS in Africa, the continent that currently harbours about 80% of the estimated 31 million cases in the world\(^\text{1}\). Until relatively recently, East and Central Africa, an area accounting for only 15% of the total population of sub-Saharan Africa, harboured 50–65% of the global burden of HIV-infection/AIDS\(^\text{4}\). About 87% of the HIV-positive children in the world live in Africa\(^\text{1}\).

Most countries in Africa are presently experiencing an accelerated growth of the urban populations at the expense of the rural communities\(^\text{5}\). Associated with this demographic change is a shift in the dietary patterns and habits, particularly a marked increase in the consumption of refined carbohydrates and lipids with a fall in total cereal and fibre intake, often resulting in the coexistence of problems of undernutrition and overnutrition\(^\text{5}\). Thus, noncommunicable diseases are escalating in importance in many African countries still beset with the serious problems resulting from infectious diseases\(^\text{6,7}\). A recent comprehensive report by Petersen\(^\text{1}\) underscores the rapidly changing global disease patterns, and the close links between oral health status and lifestyles, including dietary practices, as well as abuse of alcohol and tobacco. Our report focuses specifically on the dietary habits/nutritional status of Africans in relation to the prevalent oral health problems of the people, particularly developmental defects of the enamel, dental caries, periodontal diseases, and other inflammatory oral pathologies.

**Definition of terms and brief review of nutrition in Africa**

For the maintenance of optimal health, a well-balanced diet consisting of a complex mixture of good quality macronutrients (carbohydrates, lipids, and proteins) and micronutrients (vitamins and minerals), plus water is required\(^\text{8}\). Nutrition refers to processes involved in ingestion and utilisation of foods for growth, maintenance, and repair of the body. Malnutrition is a generic terminology for the pathophysiological consequences of the ingestion of inadequate, excessive, or unbalanced amounts of nutrients as well as the impaired utilisation of ingested nutrients often resulting from pre-existing infections and diseases\(^\text{1,4,9}\). Dietary practices of Africans have been examined in previous reviews\(^\text{1,10}\). The amounts of food consumed in a day do not usually provide the recommended dietary allowance (RDA) for energy, proteins, essential fatty acids, and the micronutrients\(^\text{10,11}\). The dietary energy supply (DES) per capita per day in sub-Saharan Africa in the last decade was less than 60% of the supply in North America or Western Europe, and food production continued to lag behind population growth rate\(^\text{1,11}\). Exclusive breast feeding is critical for child survival in sub-Saharan Africa, but its prevalence in the first month of life is as low as 2–12% in many communities\(^\text{12}\). In such settings, the complementary foods fed to the children are not only of poor nutritional quality, but are also microbiologically hazardous, thus promoting the occurrence of repeated episodes of diarrhoea and other infections\(^\text{13,14}\). The new cases of malnutrition (moderate and severe) reported in Africa were about 19 million in 1998\(^\text{1}\). As indicated in Table 1, data compiled for several African countries in 2000 revealed a high prevalence of anaemia in pregnant women and this could be attributed to deficiencies of several nutrients (e.g. iron, folic acid, vitamin A, vitamin B\(_12\)) and many parasitic infestations such as malaria, hookworm and schistosomiasis, among others\(^\text{3,12}\). Poor nutrition in pregnancy, in combination with infections, is a common cause of intrauterine growth retardation (IUGR) and low birth weight (LBW)\(^\text{3}\). Prolonged impairment of cell-mediated immunity (CMI) is a long lasting feature of children with IUGR, and they consequently have diminished resistance to infectious diseases\(^\text{3,15}\).

A recent report\(^\text{1}\) estimates that more than 2 billion people worldwide, particularly pregnant women and young children are at risk of

<table>
<thead>
<tr>
<th>Country</th>
<th>Average birth per woman</th>
<th>Maternal death per 100,000 births</th>
<th>Low birth weight per all births %</th>
<th>Pregnant women with anemia %</th>
</tr>
</thead>
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<td>800</td>
<td>20</td>
<td>43</td>
</tr>
<tr>
<td>Kenya</td>
<td>4.4</td>
<td>590</td>
<td>16</td>
<td>57</td>
</tr>
<tr>
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<td>530</td>
<td>14</td>
<td>80</td>
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<td>Ethiopia</td>
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<td>16</td>
<td>47</td>
</tr>
<tr>
<td>Uganda</td>
<td>7.1</td>
<td>510</td>
<td>16</td>
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deficiencies of vitamin A, iodine, iron, zinc, folate, and the B-complex vitamins, with the prevalence especially high in sub-Saharan Africa and Southeast Asia (Table 2). Studies in several African countries during the last decade suggest that as many as 30–67% of the children are vitamin A deficient. The pathophysiological consequences of PEM and micronutrient deficiencies in relation to growth/development, infections and immunity are subjects of several reviews. An important underlying premise of our report is that the dysregulation of various parameters of the host defence system that occurs in malnutrition, influences the vulnerability of the oral tissues to hostile pathogens.

Poverty, growth retardation and stunting of children in Africa

Growth assessment is the single measurement that best defines health and nutrition of infants/children, and it is related to the socio-economic environment in which they live. Stunting, also known as linear growth retardation (diminished height for age in relation to a reference standard) in developing countries usually starts at 3–4 months postnatally and continues until about 18–20 months of age. However, some workers believe that it probably reflects a continuing failure to grow that starts prenatally. Linear growth retardation (LGR) is associated with the introduction of locally prepared contaminated weaning foods to an immature infant, and the occurrence of impaired epithelial integrity of the gut. Malnutrition is believed to account for less than 40% of the variance in occurrence of LGR which is attributed mainly to continuous burden of immunostimulation by environmental antigens. The prevalence of stunting in several African countries (e.g. Nigeria, Uganda) is as high as 50% in the child population. There are reports that in the malnourished, oral epithelium, like the linings of the gut and respiratory tract, undergoes marked atrophy.

Studies in Nigeria, Peru, Saudi Arabia and other countries have demonstrated very significant correlation between developmental defects of the enamel (DDE), particularly in the primary dentition, and the occurrence of stunting and low birth weight in children. Enteropathy of the gastro-intestinal tract is also statistically related to prevalence of DDE of primary teeth. Eruption of the primary teeth is retarded in stunted children, and there is good evidence that enamel hypoplasia is a significant independent predictor of caries in the primary dentition.

Dental caries in Africa

According to the year 2000 WHO’s Global Data on DMFT Index, the dental caries level in Africa is low relative to findings in the Americas. Caries is considered a good proxy measure for socio-economic development and is reported to be on the increase in the rapidly industrialising African countries, particularly in the urban communities. Caries prevalence in South Africa, for example, compares closely with reported values from the industrialised Western countries and is higher in Whites and Coloured South Africans than in Blacks, with the Indians in between. In contrast, Cleaton-Jones and Fatti reported a predominantly downward trend in caries prevalence in Africa, particularly in the 5–6yr and 35–44yr age groups, despite evidence of increase in sugar consumption. Factors involved in the aetiology and pathogenesis of caries include plaque bacteria, flow rate and composition of saliva, ingestion of carbohydrates, particularly refined sugars, and the host’s status in terms of fluoride and other essential minerals like calcium and phosphorus. Oral hygiene is generally poor in many African communities despite extensive use of chewing sticks. For practical and economic constraints, many African populations have little or no access to the caries-preventive benefits of fluoride. There are however several countries in Africa and the Eastern Mediterranean where dental fluorosis is endemic as a consequence of high fluoride contents of drinking water from deep wells, foods, and other sources.

Generally, caries experience increases with sugar consumption, particularly in the developing countries with limited access to fluoride. Despite the difficulties in accurate determination of sugar intake, it was estimated that in 1993, 25 out of 41 African countries examined had intakes of less than 15kg/person/year. Often left out in such estimates is the widespread consumption of sugar cane and other sugar-containing products like sweetened soft drinks.

A dramatic increase in prevalence and severity of caries is reported as sugar intake increases from about 15kg to 35kg/person/year, and Sheiham has suggested that safe intakes (per person/yr) could be up to 10kg and 15kg in the absence and presence of fluorides respectively. A Joint WHO/FAO Expert Consultation recommends sugar consumption of less than 10% of total energy intake for caries prevention. A very recent report indicates that in South Africa, added
sugar accounts for 5.9% of the total energy intake in the rural areas compared to 12.3% in the urban communities. The traditional African foods contain a lot of starches, which are converted to a limited extent to soluble sugars such as glucose by salivary enzymes. With urbanisation, there is increased consumption by some Africans of foods with a low sugar-high starch ratio, and for reasons that are still poorly understood, these foods have been suggested to be more caries-promoting than either a high sugar-low starch or medium sugar-medium starch diet. This requires further studies.

**Periodontal diseases in Africa**

The global distribution of inflammatory periodontal disease (gingivitis and periodontitis) between and within countries shows marked racial and socioeconomic disparities, with Africans and the underprivileged most predominantly affected. In Africa, gingivitis is widespread and could be severe in children. Acute necrotising gingivitis (ANG), which is now rarely seen in the western world, is still frequently encountered in sub-Saharan African countries and it disproportionately affects impoverished children aged 3 years to puberty. The reported prevalence varies from 2.0–11.7% in the rural communities, and may be as high as 27.6% in clinic patients. There is also evidence of marked seasonal variation in its occurrence. Occurrence of shallow periodontal pockets is common in African adolescents and adults, but deep pockets necessitating tooth loss are infrequent. The aetiology of periodontal diseases involves some specific Gram-negative microorganisms (Porphyromonas gingivalis, Tannerella forsythia (formerly known as Bacteroides forsythus), Actinobacillus actinomycetemcomitans, and the helicobacter). There is however increasing evidence that the pathogenesis of periodontitis is largely dependent on the host's response to the microbial factors. The risk factors for periodontal diseases are reported to include endocrine dysfunctions, immunological defects, disease states, poverty, stress (physical and psychological), drugs (alcohol, smoking, pharmacologics), and poor oral hygiene, among others. Many of these factors are not independent of the influence of diet and nutrition.

Perhaps, no inflammatory oral lesion underscores the importance of good nutrition in oral health as noma (cancrum oris), a severe infectious disease which destroys the soft and hard tissues of the oral and para-oral structures, particularly in malnourished children aged 2 to 6 years. Noma, often described as the 'Face of Poverty' in the developing world is believed to be on the increase in sub-Saharan Africa, although reliable epidemiological data are not available. Estimates of noma per 1,000 children aged birth to 6 years for Niger, Nigeria, and Senegal are 1.34, 0.80, and 0.7–1.2 respectively. There may be as many as 12 cases per 1,000 in some of the most affected communities. The recent study by Fieger et al. puts the frequency of noma in North-West Nigeria as 6.4/1,000 children.

The environment in which noma thrives is usually characterised by mass poverty, severe malnutrition, unsafe drinking water, unsatisfactory sanitation, high prevalence of such diseases as malaria, measles, diarrhoea, acute necrotising gingivitis (ANG), and high exposure of the people to zoonoses.

**Nutrition and oral cancer in Africa**

A strong association exists between common forms of cancer and human life-style, and the term nutritional oncology recognises that cancer is a chronic disease of the genome and thus may be influenced at many stages in its natural history by nutritional/dietary factors. Oral squamous cell carcinoma (SCC), the main type of oral cancer, exhibits marked ethnic/racial disparities in incidence. In India, SCC ranks first among all cancer sites. The literature on SCC prevalence in Africa is sparse, but there are suggestions of an increase in recent years, particularly in younger age groups than is the case in developed countries.

The key risk factors for SCC are abuse of tobacco (smoking and smokeless) and excessive alcohol consumption, and both habits pose severe nutritional costs to the host. Apart from direct toxicity to many organs, alcohol elicits deficiencies of several key micronutrients such as folate, selenium, ascorbate, carotene and -tocopherol, resulting in oxidative stress and hypomethylation of DNA. Very low levels of the important antioxidant carotene (0.14pmol/10^9 cells) have been reported in exfoliated oral mucosal cells of heavy alcohol drinkers compared with the levels (2.17pmol/10^9 cells) observed in non-drinkers. Similarly, smoking depletes the cellular contents of anti-oxidant nutrients, particularly ascorbate.

**Discussion**

An individual's genetic potential for somatic growth and maturation is affected by environmental factors, and it is now widely accepted that size at birth is more dependent on maternal nutrition and health, as well as intrauterine and placental factors, than on the genetic blueprint. Worldwide, the single most common cause of growth retardation is poverty-related malnutrition which is usually compounded by infections, and the latter are very prevalent in African children as well as in pregnant and lactating mothers. Development of the dentition commences pre-natally and thus, is vulnerable to a poor nutritional environment as reflected in...
the high frequency of dental dysplasias in developing countries. Equally relevant and perhaps more ominous for oral health in Africa is the increasing evidence that nutritionally-mediated intrauterine growth retardation may permanently impair the development of immune function, particularly cell-mediated immunity (CMI). In effect, an organism’s nutritional experience during critical periods of ontogeny does have permanent effects on subsequent responses to its environment. Thus, promotion of good oral health, particularly in poor communities, must address the nutrition and infection control needs of pregnant women.

The commonest oral diseases, caries and periodontal pathologies, are generally infectious diseases, and the complex synergistic interactions between infections, malnutrition and impaired immunity are well-documented. The three-way relationship is further complicated by reports that malnutrition not only impairs the host’s responses to the invading organisms but may confer increased pathogenicity to the latter. For example, oxidative stress resulting from inadequate antioxidant status (e.g. deficiencies of selenium, glutathione) alters the mutational rate and pathogenicity of influenza virus, mesoasparagine and the normally avirulent B3-coxsackievirus. Marked tissue depletion of the key antioxidant micronutrients (e.g. α-tocopherol, β-carotene, retinol, ascorbic acid, zinc, selenium) and γ-glutamylcysteinyl-glycine (GSH) occurs in African children with protein-energy malnutrition (PEM). Additional to their key roles in various immune parameters, these micronutrients are involved in the maintenance of structural and functional integrity of mucosal epithelial cells, DNA synthesis, haemopoiesis, and in many other physiological and metabolic functions. GSH accounts for more than 90% of the cellular non-protein thiols and contributes significantly to the antioxidant network system. It also plays a major structural role in synthesis of leukotrienes and formation of the cyclooxygenase product (prostaglandin E2), both of which are important mediators of inflammation. Prominent impairment of arachidonic acid metabolism, particularly synthesis of the leukotrienes has been reported in GSH deficient children. The latter may affect endogenous production of lipoxins (LXs) which are trihydroxytetraene-containing eicosanoids typically generated during cell-cell interactions. Lipoxins provide counter-regulatory signals to the pro-inflammatory mediators (e.g. leukotrienes, prostaglandins) and their reduced production is probably relevant to severe periodontitis seen in underprivileged malnourished Africans.

The immunological changes in PEM show marked similarities to those encountered in HIV-infection/AIDS, a disease characterised by severe lesions of the oral tissues. Innate and adaptive host defences are compromised in both health conditions. Secretory immunoglobulin A (sIgA), a principal component of the mucosal immune system whose synthesis and expression into secretions prevent bacterial and viral adherence to mucosal epithelial cells, is reduced in malnutrition. The number of gobbet cells involved in mucus production is reduced, particularly in the presence of vitamin A deficiency. Malnutrition in African children, also elicits increased production/secreotion of the stress hormones (i.e., glucocorticoids and catecholamines), with abolition of the usual cortisol rhythm. The latter raises serious potential consequences because the cortisol rhythm normally imposes a diurnal variation on immune function with periods of intense immune activity following the early morning nadir in plasma cortisol level. It is perhaps relevant that psychological stress, a risk factor for periodontal inflammation, promotes a reduction in CD4, T-cell numbers, NK-cell activity, and proliferative response of lymphocytes to mitogens, among other immune changes. Experimentally induced periodontitis in animals responds favourably to treatment with the glucocorticoid receptor antagonist mifepristone (RU486). It should also be noted that increased blood level of cortisol in PEM implies a similar change in the saliva and gingival crevicular fluid. Modification of the inflammatory aspects of immune function by nutrition may also occur through the actions of cytokines and growth factors. Significantly increased plasma concentrations of the pro-inflammatory mediators, interleukin(IL)-6, tumour necrosis factor (TNF) and its soluble receptors (sTNFR-p55 and sTNFR-p75) have been reported in infected and non-infected malnourished African children compared with values in healthy children.

Diet and nutrition of the host may determine the occurrence of oral diseases through their influence on ecology of the oral microflora. In the mouth, only mucosal surfaces are available for bacterial colonisation during the first few months of life and s-IgA constitutes the main defence mechanism by inhibiting bacterial adherence. Synthesis of s-IgA is compromised in malnutrition. The surroundings and feeding pattern of infants affect the composition of bacterial species involved in the early colonisation. The composition of the oral flora in healthy children usually differs from that of adults. However, studies in malnourished African children have revealed very prominent recovery of the anaerobic periodontopathic organisms usually associated with periodontal diseases in adults. These malnourished children, aged 2–8 years, are serologically negative for HIV-infection/AIDS, and show increased oral carriage of vari-
ous species of yeast. Reasons for the differential overgrowth of anaerobic organisms in the mouths of malnourished African children have been reviewed, and may include disruption of the homeostatic mechanisms between the oral microflora by dietary stresses, hormones, changes in saliva volume and composition, microbial products and defects in the host’s defences.

The oral epithelium and components of the extracellular matrix are characterised by a high turnover rate, and thus, adequate nutrition is necessary for rapid replacement of cells and tissue components damaged by microbial challenge. With regard to the host’s response to the microbial challenge in periodontal diseases, intact epithelial barrier of the gingival, sulcular and junctional epithelium is a relatively effective barrier against penetration by bacterial products. Breaching of the oral epithelium seen in malnutrition, particularly in deficiencies of vitamin A and zinc, as well as immune deviations caused by cytokines, are events undergirding abrogation of oral tolerance. Although nutrient deficiencies and imbalance may not initiate periodontal diseases in the absence of plaque, they do have the potential to influence the biological gradient and natural history of the lesions.

The five basic goals of primary health care are the promotion of food supply, proper nutrition, adequate supply of safe water, family planning and the prevention of infectious diseases. All these goals are directly or indirectly related to dietary practices and to nutrition. Hunger and malnutrition remain the most devastating problems that continue to dominate the health (including oral health) of the world’s poorest nations that include many of the countries in Africa. Immunological competence and nutritional status are among the most important determinants of mortality and morbidity, and adequate attention to these two interdependent indices are central to the solution of oral health problems in Africa.

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References

27. Alvarez JO, Caceda J, Woolley TW, et al. A longitudinal study of dental caries in the primary teeth of children who suffered from infant malnutri-


