10

Oral Health and Nutrition

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1. Introduction

Nutrition and diet affects the development and integrity of the oral cavity as well as progression of diseases of the oral cavity, and are major multifactorial environmental factors in the aetiology and pathogenesis of oro-facial diseases and disorders (US Department of Health and Human Services 2000). Oral health means more than good teeth; it is integral to general health and essential to well-being (Petersen 2003). The interrelationship between oral health and general health has been proven. Severe periodontal disease, for example, is associated with diabetes (Grossi & Genco 1998). The strong correlation between several oral diseases and noncommunicable chronic diseases is primarily the result of common risk factors (Sheiham &Watt 2000). Oral health and nutrition have a synergistic relationship. Oral infectious diseases, as well as acute, chronic and terminal systemic diseases with oral manifestations, impact on the functional ability to eat while also having an impact on diet and nutrition status. Despite great achievements in the improvement of oral health of populations globally, problems still remain in many communities. The significant role of socio-behavioural and environmental factors in oral disease has been demonstrated by a large number of epidemiological surveys (Petersen 2003).

Dental caries is a global disease with few populations exempt from its effects. In developed countries, widespread reduction of dental caries in childhood has led to the development and recognition of high caries risk communities who have failed to benefit from prevention and are often excluded from regular use of healthcare systems (Gratrix & Holloway 1994). The communities are often of low socio-economic status, where minority ethnic groups are over-represented and general health and living conditions are poor (Acheson 1998).

In developing countries, as development increases, so does dental caries, and children are at the forefront of disease disadvantage (Chen 1995). Internationally, there is a growing realization of the need to accurately identify high caries risk groups, to commence prevention from a young age and to examine the effect of early intervention in childhood on general and dental health with both population and high-risk approaches (Pine 1997). Critical aspects to consider include the social and cultural aspects around child development, including family stress, and access and use of health services; nutrition, including access to fluoride and use of sugar; composition and activity of the oral microflora; and a recognition of behavioural and biological impacts on health. Published research has looked at associations between key risk factors and the development of dental caries cross-sectionally and some longitudinally (Hausen 1998). However, in developing countries, little is known of the interactions vertically in the paradigm between molecular

impacts and psychosocial impacts, particularly within and between ethnically diverse or disadvantaged, impoverished populations.

2. Dental caries

Diet and nutrition have a direct influence on the progression of tooth decay. The overall nutrient adequacy of an individual's diet may be the best indicator of caries risk. Diets that promote variety and moderation are going to contribute to both oral and general health (Mobley, 2003). Dental caries is a diet-dependent infectious disease primarily attributed to the presence of oral bacteria. Its prevalence and progression is influenced by other factors including saliva, fluoride and the integrity of enamel (Konig, 2000). Preventive dental regimens are designed to maintain the equilibrium in the dynamic demineralization–remineralization of the tooth surface (Featherstone 2000). Nutrition systemically influences teeth during the pre-eruptive stage, including prenatal, perinatal and postnatal periods. Protein energy malnutrition and deficiencies of vitamins A and D have been associated with enamel hypoplasia and an increase in the susceptibility to caries (Alvarez, 1995).

The evidence shows that sugars are undoubtedly the most important dietary factor in the development of dental caries and the disease is most strongly associated with sugar consumption, in the absence of regular exposure to fluoride (Burt & Satishchandra, 2001). The ability of oral bacteria, most notably *Streptococcus mutans,* to ferment sucrose and other sugars into acid, producing a sustained pH lower than 5.5, is the basis of the demineralization process that is capable of destroying tooth enamel and eventually leading to tooth loss. The biochemistry of disaccharide breakdown and the formation of sticky levans and dextrans in the formation of plaque on the tooth surface, providing a protected reservoir for bacterial acid production right on the tooth surface, is also well-established.

The frequency and the total amount of sugar-rich foods consumed have both been strongly correlated to dental caries and also to each other, suggesting that strategies to control one variable will contribute to controlling the other (Sheiham 2001). Other researchers (Ismail *et al*. 1984; Jamel *et al*. 1997) have shown the danger of consuming sugar in forms that are very sticky (have strong adhesive properties) as these are cleared from the mouth by saliva very slowly. Factors determining the cariogenic, cariostatic and anti-cariogenic properties of the diet are food consistency (liquid, solid, sticky, long-lasting), frequency of consumption of sugar and other fermentable carbohydrates, nutrient composition, potential to stimulate saliva, sequence of food intake and combinations of food (Papas *et al*. 1995; DePaola *et al*. 1999; König 2000).

The role of diet in dental caries incidence and prevalence is reflected in dietary patterns that are a combined consequence of food choices, the food eaten and the frequency of dietary intake in a specific time period (Mobley, 2003). Strategies need to be developed to assess food choices that combine caries-promoting and cariostatic foods. Calcium and fluoride-rich foods enhance the potential for remineralisation.

3. Nutrition and early childhood caries

A child's diet has a profound ability to influence cognition, behaviour, emotional development, physical growth and development. Nutrients from food provide energy for growth, serve as structural components and partake in the metabolic functions of the body.

Guidelines for dietary habits and food choices are designed to provide adequate energy and nutrient intake to support growth.

Dental caries is widely recognized as a preventable infectious disease that is strongly modified by diet. The main players in the aetiology of the disease are cariogenic bacteria, fermentable carbohydrates and a susceptible tooth and host. However, in young children, bacterial flora and host defence systems are in the process of being developed, tooth surfaces are newly erupted and may show hypoplastic defects, and carers must negotiate the dietary transition through breast/bottle feeding, first solids and childhood tastes and it has been reported that there may be unique risk factors for caries in infants and young children (Seow 1998).

Early childhood caries (ECC) in infants and preschool children is a preventable dental disease. It affects a disproportionate number of children from low socio-economic groups and ethnic minorities. Milnes (1996) reported that while the prevalence rate of ECC varied from 1% to 12% in developed countries, in developing countries and within disadvantaged populations of developed countries (immigrants, ethnic minorities), the prevalence rate is as high as 70%. The presentation of a child suffering from rampant caries is, as described by Fass (1962), a shocking experience. He published the first comprehensive description of caries in infants, which he termed 'nursing bottle mouth'. The clinical appearance of ECC includes the form of caries affecting all the primary upper anterior teeth, upper and lower primary first molars and the lower canines (the lower anterior teeth remain unharmed) to rampant caries affecting all the teeth in the mouth or small 'pockets' of decay affecting a single tooth in children between 1 and 5 years old.

The causes of early childhood caries are complex, but understanding the aetiology of the disease has a direct influence on public policy. In the United Kingdom, the British Society of Paediatric Dentistry recommends a reduction in sugar intake by the whole child population in the country, whereas its American counterparts' view is that sugar restrictions can be relaxed in a society where fluoride is used frequently, particularly for children who have low or no caries (British Society of Pediatric Dentistry 1992; American Academy of Pediatric Dentistry 1989). The aetiology of ECC is multifactorial – the presence of oral bacteria and fermentable carbohydrates are necessary, but proper oral hygiene and regular fluoride exposure reduce the risk of caries. The design of interventional programmes set up to prevent the disease is influenced by how the aetiology is interpreted. It has been established that a group of cariogenic micro-organisms, oral streptococci, is associated with ECC. Oral levels of these bacteria, which are generally acquired from the mother, were found to be elevated in children with ECC (Tinanoff & O'Sullivan 1997). Other contributing factors that predispose children to ECC include prolonged and night-time bottle feeding of milk and/or sweetened juice in infants and toddlers, nocturnal breastfeeding after 12 months of age, linear hypoplasia of primary teeth associated with malnutrition and the prolonged use of a pacifier covered with honey, sugar or other sweetened foods (Tinanoff & O'Sullivan 1997; van Palenstein Helderman et al 2006).

3.1 Protein energy malnutrition/failure to thrive

ECC has also been implicated as contributing to other health problems: children with ECC were shown to weigh less than 80% of their ideal weight and to be in the lowest 10th percentile for weight (Acs *et al*. 1999). Protein energy malnutrition is defined as weight or height less than the 5th or 10th percentile for age and failure to thrive implies a deficit in expected growth and in one or more areas of psychosocial development (Wright, 2000). The mean age of 'low weight' patients with ECC was significantly greater than for patients at or

above their ideal weights, indicating that progression of ECC may affect growth adversely. In addition, the quality of life of the child suffers – pain or infections associated with ECC may make it difficult for the child to eat. Alternatively, poor nutritional practices may be responsible for both the reduced weight and caries. Low *et al*. (1999) reported on the effect of severe caries on the quality of life in young children. They found that there was a significant change in pain complaint, eating preferences, quantity of food eaten and sleep habits before and after treatment of dental caries. Finally and most importantly, the cost of restoring decayed teeth in ECC is extremely high (Weinstein 1998).

3.2 Implications of early childhood caries

Early childhood caries is characterized by a high prevalence, high impact and high resource requirements. Its seriousness and societal costs continue to be a significant public health issue, especially among racial or ethnic minorities (Tinanoff & O'Sullivan 1997). There is considerable evidence that children who experience ECC continue to be at high risk for new lesions as they grow older, both in the primary and permanent dentitions (Johnsen *et al*. 1987; Kaste *et al*. 1992; O'Sullivan & Tinanoff 1996). It has not been established whether it is the high levels of infection by cariogenic organisms or the establishment of poor nutritional practices that are the determinants of caries progression (Litt *et al*. 1995).

Treatment of ECC is expensive, often requiring extensive restorative treatment and extraction of teeth at an early age. In the US, the estimated costs of restoring teeth alone is thought to exceed U$1000 per child (Jones *et al*. 1995). In addition to these expenses, general anaesthesia or deep sedation may be required because such young children lack the ability to cope with surgical procedures. Thus, the consequences of ECC are a significant problem not only in monetary terms to parents and the government, but also in potential risks to health and comfort of the child.

3.3 Prevention of early childhood caries

There are three general approaches that have been used to prevent ECC. The first is a community-based strategy that relies on the education of mothers or caregivers in the hope of influencing their dietary habits as well as those of their infants (Ripa 1988). This approach also uses water fluoridation and community preventive programmes in high-risk communities. The second approach is based on the provision of examination and preventative care in dental clinics. The third involves the development of appropriate dietary and self-care habits at home. All three approaches use the mothers or caregivers to follow healthy dietary and feeding habits in order to prevent the development of ECC, as patterns in the introduction of foods and when eating behaviours are established, may be influential in its prevention and treatment (Garcia-Godoy *et al*. 1995; Tinanoff & Palmer 2003). The goal of the educational initiative is to increase the knowledge of the mother and to improve the dietary and nutritional habits of the infants and mothers. It is assumed that an increase in the knowledge f mothers or caregivers will influence their self-care habits and dietary practices and in turn improve the dietary and oral hygiene habits of the infants leading to the prevention of ECC.

4. The role of fluoride in nutrition

There is no specific nutritional requirement for fluoride and it is usually recommended as a means of caries prevention. The role of fluoride in protecting teeth against dental caries is

well-established (Warren & Levy, 2003). It remains the cornerstone of caries prevention and there are a variety of sources that contribute to the dietary intake of fluoride. However, the association between the frequency of sugar intake and dental caries is negated only partly by the presence of fluoride (Stecksen-Blicks & Holm 1995). In fact, the beneficial effects of fluoride vary according to the amount of sugars consumed (Kunzel & Fischer 1997). For example, there is a dramatic increase in the prevalence and severity of dental caries when sugar intake increases from around 15 kg to 35 kg per person per year (Takahashi 1961; Sheiham 1987). On the basis of this evidence, Sheiham (1991) recommended that in the presence of fluoride, a 'safe' intake of sugars would be up to 15kg per person per year and in the absence of fluoride, up to 10 kg.

5. Water fluoridation – Where are we now?

With the availability of fluorides targeted at individuals and the decline in dental caries, the need for water fluoridation has been questioned (Kumar, 2008). Water fluoridation is the process of adjusting the amount of fluoride that is present naturally in a community's water to the optimal level for protection against tooth decay. It is a cheap and efficient public-health measure for the delivery of fluoride in many countries. It is the most cost-effective way of preventing tooth decay. Optimum fluoride levels in the water strengthen the teeth and reduce tooth decay by up to 60% (Pizzo *et al*. 2007). It is 18 times cheaper than toothpaste and 61 times cheaper that filling one tooth (van Wyk *et al*. 2001). The advantages of water fluoridation include its ability to deliver low levels of fluoride in saliva frequently and the potential to reduce oral health disparities by creating a healthy environment. Communities need to discuss issues about fluoridation with regard to available caries-prevention strategies, disease burdens, feasibility, cost and use of other forms of fluorides. Currently, water fluoridation remains the best tool to combat caries and to reduce disparities among socially disadvantaged groups within communities.

6. Dental erosion

Dental erosion is the chemical dissolution of dental hard tissues by extrinsic and/or intrinsic acids without bacterial involvement. It is commonly associated with dietary practices involving the frequent intake of acidic food and beverages (Scheutzel 1996; Zero 1996; Parry *et al*. 2001) that weaken the integrity of the tooth and increase caries risk. Extrinsic dietary acids include citric, phosphoric, ascorbic, malic, tartaric and carbonic acids that are found in fruits, fruit juices, soft drinks and vinegar. Dental erosion may progress into the dentine and pulp, with consequent tooth sensitivity, altered occlusion and poor aesthetics. The scientific interest in dental erosion has dramatically increased during the last decade and it is now recognized as an important cause of loss of tooth tissue in children. Furthermore, the reduced thickness of enamel and greater acid solubility in the primary dentition contribute to a higher susceptibility to erosion (Shaw *et al*. 1998; Harley 1999). Age-related increases in dental erosion have been shown to be greater in those with the highest intake of soft-drinks.
The prevalence of erosion is associated with social and dietary factors (Millward *et al*. 1994; Hinds & Gregory 1995; Malik *et al*. 2001; Luo *et al*. 2005).There is a positive correlation between higher parental educational levels and erosion in children. Previous studies reported inconsistent findings on the relationship between erosion and social factors: Luo *et al*. (2005) and Millward *et al*. (1994) found that children from low socio-economic groups had

less erosion, while others found an inverse relationship that as social deprivation worsened, the presence of dental erosion increased (Hinds & Gregory 1995; Harding *et al*. 2003). A focus on the importance of improved dietary habits for good oral health as well as good general health should be included in counselling.

7. Periodontal diseases

Periodontal diseases are oral infectious diseases involving inflammation and loss of bone and supporting tissues of the teeth. Gingivitis and periodontitis are chronic infectious diseases. Although its pathogenesis involves bacteria, there are local and systemic host and environmental factors that influence the severity and progression of the disease (Nishida *et al*. 2000).

Dental plaque is a complex environment called a biofilm. Nutrition has both direct and indirect effects on the development and composition of plaque biofilm (Boyd & Maddon, 2003): (i) through a direct supply of nutrients (such as sugar) as substrates for energy, nitrogen or carbon for the bacteria; (ii) by having an effect on the production of metabolic by-products from one organism that provides nutrients for other organisms (Bowden & Li, 1997); (iii) through the production of specific polymers by other bacteria and finally (iv) by altering the environment of the biofilm and thereby influencing bacteria to colonise the biofilm.

The interaction between nutritional status and the immune response to the bacterial challenge is an underlying factor in the progression of periodontal disease. Nutrient deficiencies (vitamin C and calcium) may compromise the systemic immune response to inflammation and infection and alter nutrient needs (Nishida *et al*. 2000; Krall 2001). In addition, it can also compromise the associated inflammatory response and wound healing (DePaola *et al*. 2002). Nutritional status has a direct influence on the synthesis and release of cytokines and their action (Psoter *et al*. 2005). Consequently, malnutrition is associated with increased needs for calories and protein to promote repletion, wound healing and an improved immune response. Malnutrition also has an adverse effect on the volume, composition, antibacterial and physiochemical properties of saliva. Undernutrition exacerbates the severity of oral infections and may eventually lead to other life-threatening diseases such as noma (Enwonwu 1995).

Good nutritional status and dietary practices combined with the removal of the stimuli of the inflammatory periodontal response are important in reducing the severity of periodontal diseases and to promote optimal periodontal health.

8. HIV/AIDS

The oral manifestations of HIV infection include fungal, viral and bacterial infections. Neoplasms, periodontal disease, salivary gland disease and lesions of uncertain origin are also seen. Oral lesions such as candidiasis, herpetic ulcers and Kaposi's sarcoma are among the first symptoms of HIV infection. Deterioration of oral health is highly correlated to deterioration of general health, making it essential for the patient to be well nourished to respond to the challenge of HIV and other infectious diseases.

Malnutrition at a global level is the most widespread condition associated with immunosuppression in humans (Enwonwu & Warren, 1994). Malnutrition in Africa is of a staggering magnitude, and worsening in some countries, especially in Sub-Saharan Africa

(Berg, 1992). Malnutrition and wasting are prominent manifestations of the late stages of HIV infection (Hecker & Kottler, 1990) and a growing number of single nutrient deficiencies have been reported in AIDS patients (Enwonwu & Warren, 1994). There is marked overlap between the immunological abnormalities caused by malnutrition and by HIV infection (Chandra, 1991). Inadequate nutrition may influence the progression from asymptomatic HIV infection to the full blown condition of AIDS as well as intensify the susceptibility to opportunistic infections and contribute to the severity of HIV-related diseases (Raiten, 1990). Protein-energy malnutrition (PEM) is a major nutritional problem and is a common complication of HIV infection (Enwonwu, 1992; Kottler, 1990). The oral mucosa and the gastrointestinal tract have relatively high cell turnovers. In PEM, the fundamental problem is poor cell production resulting in mucosal atrophy. In the oral cavity, malnutrition-induced mucosal disruptions in combination with poor oral hygiene, are expressed as candidiasis, angular chelitis, stomatitis and severe periodontal lesions (Samarayanake, 1986). Hypofunction of salivary glands in PEM results in xerostomia and failure to protect oral tissues against the numerous potentially pathogenic oral microbial organisms (FDI, 1992).

Patients with HIV infection are at risk for oral disease with accompanying nutritional and systemic consequences. For example, oro-pharyngeal candidiasis may cause a burning, painful mouth and dysphagia. Herpes simplex and cytomegalovirus infections lead to chronic, painful ulcerations. These conditions cause discomfort, difficulty with swallowing, eating restrictions and may reduce an already compromised appetite and intake. Due to the magnitude and impact of HIV-associated oral disease on dietary intake and nutritional status, dental intervention together with nutrition management is an essential component of care. Nutritional strategies need to be developed to reduce the occurrence of opportunistic infections in immuno-compromised patients.

9. Infants and children

Adequate nutrition and nutrients are needed pre-, peri- and postnatally for normal craniofacial growth and development of the oral cavity (Alvarez 1995; DePaola *et al*. 1999; DePaola *et al*. 2002). A single episode of mild to moderate malnutrition in the first year of life and/or folate deficiency was found to be associated with an increased incidence of caries in deciduous and permanent teeth later in life (Alvarez 1995).

Diet counselling is an integral part of anticipatory guidance during the infant oral health visit. Similar to dietary instructions for children of all ages, the primary emphasis is on sugar intake frequency. Maxillary anterior incisor caries as manifested in ECC is mainly due to feeding practices and is the major nutrition-related oral disease found in young children. As mentioned above, the combination of infant/ child feeding practices and repeated sequential consumption of fermentable carbohydrates, such as sweetened beverages or highly processed starchy/ sugary foods, increases caries risk.

There are, however, other infant-specific dietary issues that must also be addressed during the infant oral health visit. Bottle-fed infants should not be put to sleep with the bottle. Weaning from the bottle should be encouraged by 12–14 months of age. Infants older than 6 months and with exposure to less than 0.3 p.p.m. fluoride in their drinking water need dietary fluoride supplements of 0.25 mg fluoride per day. Only 4–6 oz of fruit juice should be consumed by infants per day. Infants should not be given powdered beverages or fizzy drinks, as these pose an increased risk for dental caries. Iron-fortified infant cereals, along

with breast milk or infant formula, should be consumed by infants who are over 6 months of age. Cow's milk should be avoided in the first year of life and restricted to less than 24 oz per day in the second year (Naidoo & Myburgh, 2007). Parents should be cautioned regarding the potential of various foods to constitute a choking hazard for infants (Nainar & Mohummed 2004; Sayegh *et al*. 2005). For school-age children, meal and snack behaviours should involve food choices that promote oral health. Other conditions that may affect oral health include developmental anomalies that alter eating ability and require specialized feeding strategies and cranio-facial surgery, which often requires increased energy, protein and nutrient needs for wound healing.

Nutrition education and counselling for the purposes of reducing caries in children are aimed at teaching parents the importance of reducing high frequency exposures to obvious and hidden sugars. Guidelines include: avoiding frequent consumption of juice or other sugar-containing drinks in bottle or cup; discouraging the behaviour of a child sleeping with a bottle; promoting non-cariogenic foods for snacks; fostering eating patterns consistent with Food Guide Pyramid and those food that have been fortified; limiting cariogenic foods to mealtimes; rapidly clearing cariogenic foods from the child's oral cavity, either by tooth brushing or by consumption of protective foods and restricting sugar-containing snacks that are slowly eaten (e.g. sweets, lollipops, suckers). Along with nutritional factors, a comprehensive approach to preventing dental caries in pre-school children must include improved general dietary habits, good oral hygiene, appropriate use of fluorides, and access to preventive and restorative dental care (Tinanoff & Palmer 2003). Policies and health promotion strategies need to be targeted to mothers from less advantaged backgrounds. Appropriate advice on infant feeding, dietary practices and oral hygiene measures should be the major focus.

10. Concluding remarks

Nutrition plays an important role in the maintenance of the optimal functioning of the immune response. Individuals who are undernourished have impaired immune responses including abnormalities in adaptive immunity, phagocytosis and antibody function. Many countries that are undergoing nutritional transitions may not have adequate exposure to fluoride. There is a call for the promotion of adequate fluoride exposure via appropriate vehicles like affordable toothpastes, water, salt and milk (WHO/FAO, 2003).

Because a healthy, functioning oral cavity is a necessary part of mastication and digestion, a comprehensive oral health module should be incorporated into the training of all health sciences students. The outcomes should include detection of nutrition and diet-related risk factors for oral health and referral to an oral healthcare worker for any abnormal findings. The need for oral health professionals to facilitate patient referrals has been identified (Greenspan *et al*. 1995; Touger-Decker & Gilbride 1997). Health sciences students should be given opportunities to work in oral health settings together with dental students to provide competency in oral examination, identification of oral risk, nutrition and diet advice and interventions.

The joint World Health Organization/Food and Agricultural Organization (WHO/FAO) expert recommendation (WHO/FAO 2003) calls for international organizations to recognize nutrition as an essential part of training of oral health professionals, as well as an important part of educational programmes for dietetics and other health professionals. Oral health and nutrition experts should assume leadership in promoting this dual curriculum content area

of allied health professionals. Oral health professionals need to form networks with other members of the healthcare team (physicians, nurses, speech and language therapists, etc.) to advance health promotion and preventive initiatives that promote oral health and nutrition as they relate to general health.

Partnerships need to be forged between national dental organizations, local and national governmental structures and the private sector to alleviate the barriers (physical, cultural, racial, ethnic, social, educational, environmental and healthcare delivery) that prevent people from achieving oral health and to enhance and support appropriate research that explores new ways of improving nutrition and oral health for all.

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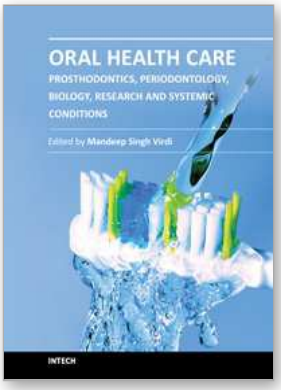

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Geriatric dentistry, or gerodontics, is the branch of dental care dealing with older adults involving the diagnosis, prevention, and treatment of problems associated with normal aging and age-related diseases as part of an interdisciplinary team with other healthcare professionals. Prosthodontics is the dental specialty pertaining to the diagnosis, treatment planning, rehabilitation, and maintenance of the oral function, comfort, appearance, and health of patients with clinical conditions associated with missing or deficient teeth and/or oral and maxillofacial tissues using biocompatible materials. Periodontology, or Periodontics, is the specialty of oral healthcare that concerns supporting structures of teeth, diseases, and conditions that affect them. The supporting tissues are known as the periodontium, which includes the gingiva (gums), alveolar bone, cementum, and the periodontal ligament. Oral biology deals with the microbiota and their interaction within the oral region. Research in oral health and systemic conditions concerns the effect of various systemic conditions on the oral cavity and conversely helps to diagnose various systemic conditions.

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