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Oral Health

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In contrast to most other diseases, some of the oral diseases are well known and experienced by most people, albeit perhaps only to a mild degree. Those readers, however, who have had toothaches or jaw infections may testify that oral health problems can be so dominant that practically all other problems fade into insignificance until help is received—and, if professional help is not available, removing the aching tooth may be another never-forgotten experience.

A variety of diseases affect the oral cavity. Dental caries, the disease causing cavities in the teeth, is common worldwide. Untreated caries may lead to infection in the pulp, an infection that may spread to the supporting tissues and the jaws, with or without pain to the individual. Other common diseases are the periodontal diseases, including inflammation of the tissues surrounding the teeth and breakdown of bone support and loss of teeth.

Further problems affecting the teeth involve the position of the teeth, varying from simple conditions like too much space between them or overcrowding to serious lip and cleft palate syndromes resulting in chaos for the formation of normal dentition. Traffic accidents, violence, and certain sports and games often involve injuries to the teeth. Disturbances in the formation of normal tooth structures may be caused by inherited diseases or, as in the case of fluorosis, by the intake of too much fluoride through drinking water or food. A number of substances may give disturbing discolorations to the teeth, either when the substances are supplied during the time of formation of the teeth or when they are added to already erupted teeth.

The soft tissues in the oral cavity may be the site of numerous conditions, involving oral cancers, symptoms of infection by the human immunodeficiency virus (HIV), or less harmful but painful conditions. Disturbances in the normal saliva flow are not uncommon and are most prevalent in elderly people; such conditions are usually very uncomfortable for the person affected and may predispose him or her to further dental problems. Unnecessary or poor quality dental care can also be the cause of oral health problems.

From this short introduction, it is clear that the oral cavity is a center for a large variety of possible diseases, some of which can be prevented, some of which can be cured only by complicated operations performed by highly skilled personnel, and some of which cannot be treated by any methods known at present. To this should be added the fact that considerable importance is attached to the oral cavity in many cultures in developing countries; this may be illustrated by traditions such as grinding of healthy teeth to certain shapes or knocking out teeth for ceremonial reasons. In industrial countries the increasing number of advertisements for dental materials, and courses, in aesthetic dentistry also reflects this importance. Because the oral cavity is the means of communication, tasting, eating, kissing, and so on, and because it is positioned at a level where it is easily observed, it is understandable that many people regard oral health as very important.

Further information regarding the etiology will be given below for some of the most prevalent oral diseases. This should not be interpreted as an underestimation of the less prevalent diseases. Certainly, such diseases may be most inconvenient or even fatal for those affected. But, from a global point of view, any changes in the prevalence of the common oral diseases will be of such significance, that we, at this stage, can be excused for making such a restriction.

Dental Caries

Dental caries is characterized by the dissolution of the hard tissues of the teeth (enamel, dentin), eventually leading to the destruction of the affected tooth surface, or of the tooth itself. The immediate cause is the organic acids produced by certain microorganisms present on the tooth. The bacteria, together with a matrix made up mainly of extracellular polysaccharides produced from sucrose by the microorganisms, form the so-called dental plaque. The acids are formed when fermentable carbohydrates are added to the plaque. Each time such a process is started, the tooth will be damaged, but if the process does not occur too often, the natural capacity of the body to remineralize the tooth will prevent the formation of a cavity.

From this simple description, some factors that influence the risk of caries disease, and cavities, can be identified:

- The tooth surface may be more or less covered by dental plaque. More plaque, especially if it contains cariogenic

microorganisms, includes more bacteria and may result in the formation of more organic acids. All methods aimed at reducing the amount of plaque, such as toothbrushing and use of antiplaque substances, thus are an attempt to reduce the amount of acids to be produced.

- Dental plaque is composed of a variety of oral microorganisms. Some of these microorganisms have a higher cariogenic potential than others. This potential includes factors such as the ability to form acids, to form acids at low pH, to survive at low pH, to adhere to the tooth, and to form extracellular polysaccharides. Among the many microorganisms identified, the so-called mutans streptococci (*Streptococcus mutans*, *Streptococcus sobrinus*), in particular, have been assigned an important role in the development of caries. Some means are now available for combating the mutans streptococci, although they are not yet in common use.
- Composition of diet, as well as frequency of eating, are further important factors. A diet with a low sucrose content, or less frequent eating, will result in reduced formation of organic acids. This knowledge has resulted in well-known advice regarding the restriction of intake of products that contain sugar and also has led to the development of less cariogenic products, which contain other sweeteners such as xylitol, sorbitol, or aspartame.
- Effective remineralization is another factor that has received increased attention. This factor is dependent on saliva flow and saliva composition, but the presence of fluoride during the active process, in the plaque fluid, has been shown to be of utmost importance. Earlier methods of employing fluorides concentrated mainly on trying to "build in" the fluorides to make the teeth more acid resistant by systemic addition of fluoride during the calcification of the teeth. Although this strategy still has some bearing, the continuous supply of fluorides even in low concentrations now attract most interest. The potential of fluoride to reduce caries has resulted in numerous attempts to use the substance, such as by adding fluoride to drinking water, salt, milk, tablets, fluoride rinses, varnishes, gels, and, of course, toothpaste.
- A number of individual factors may increase, or decrease, the risk of caries. These factors operate mainly through the saliva. Extremely low secretion rates, which, for example, may be an unwanted side effect of certain drugs, often result in high caries scores. Antibodies in the oral fluids are of particular interest because they would be the main mechanism for a caries vaccine.

The factors mentioned above: plaque, specific bacteria, diet, fluoride, and saliva are all involved in the caries process. It is important to understand what happens exactly on the tooth where a caries lesion will, or will not, occur. Once the factors have been identified, further questions will be raised: why do we have this particular combination of factors on this tooth, or in this person, or in this population? We then arrive at points for discussion of why a certain groups of people have a certain type of diet, why they do not clean their teeth, why they do not use fluorides, and so on. The answers to such questions may sometimes be found through research within community dentistry, but often they lie outside the purely odontological field.

Periodontal Diseases

Bacteria are the main cause also of the diseases affecting the supporting tissues of the teeth, and the host's response to the bacteria may result in more or less severe damage. Accumulation of bacteria on the teeth close to the tissues usually results in gingivitis, characterized by a tendency of the gums to bleed, especially when light pressure is applied, as, for example, at toothbrushing. More severe forms involve breakdown of the bone support of the teeth, resulting in more or less mobile teeth, later perhaps in the total loss of the affected teeth.

The processes leading to the more severe forms are the result of presence of bacteria in the gingival pockets and the reaction of the bacteria to the host defense systems. Research during the last fifteen years has pointed out some bacterial species as being particularly associated with periodontal diseases: *Actinobacillus actinomycetemcomitans*, *Bacteroides gingivalis*, *Bacteroides intermedius*, *Peptostreptococcus micros*, *Veillonella recta*, to name some. But bacteria may be present also in gingival pockets where no periodontal disease appears to follow, illustrating the complex interaction with the host. Periodontal diseases are not considered diseases which unconditionally follow gingivitis, although they may. Individuals at extra risk for periodontal diseases may be persons with immunodeficiencies, malnutrition, or diabetes, and those who smoke. A thorough discussion about the possibilities of identifying individuals at risk for periodontal disease was presented by Johnson (1989).

Prevention of periodontal diseases usually focuses on the dental plaques—the effective removal of the bacterial deposits, including calculus, on the teeth. Treatments of advanced stages usually include surgical methods to get access to the affected parts. Antibiotic therapy is sometimes introduced but can only be looked upon as a support for the local treatment.

Other Oral Diseases

Because dental caries and periodontal disease are or have been so common, less attention has usually been focused on other oral health problems. It would be a great mistake, however, to neglect these diseases and conditions, because they may often result in severe consequences to the person affected. In a survey of the epidemiology of oral diseases other than caries and periodontal disease, roughly one-quarter to one-half of populations examined were affected by conditions like masticatory dysfunction, traumatic dental and maxillofacial injuries, impactions, and oral mucosal disease (Andreasen and others 1986). Some examples of this survey will be mentioned below.

Regarding *dysfunction* of the masticatory apparatus, Andreasen and others reviewed five studies, all dealing with populations in industrial countries. About 25 to 50 percent of the people had subjective symptoms. The authors of the

studies pointed out that headache often follows mandibular dysfunction and that headache is a common cause of visits to physicians.

For *traumatic dental injuries*, Andreasen and others reviewed fourteen studies that summarized investigations concerning children and adolescents age three to nineteen. The frequency of dental injuries varied from 8 to 35 percent. The authors of a Danish prospective study of children eligible for the preschool dental service pointed out that every third child had experienced trauma of the primary dentition and every fifth child had sustained injury to the permanent dentition before leaving school at age sixteen (Andreasen and Ravn 1972). Data from developing countries were very sparse.

Few reports on *maxillofacial injuries* were available but those reporting data from Scandinavia and England estimated the annual incidence as being 1 to 4 per 10,000 people, traffic accidents and assault being the main cause. A remarkable higher incidence was reported from Greenland, 19 cases per 10,000, usually caused by assault following alcohol abuse.

Tooth impactions and other eruption disturbances were frequent findings in seven studies. About 20 to 30 percent of the populations investigated were affected. The conditions may lead to resorption of teeth, cysts, tumors, and inflammation, in particular, pericoronitis.

Very few studies have presented comprehensive data on the prevalence of the full range of *mucosal lesions*. One such study was performed in Sweden (Axéll 1976), and recently data have became available for most of those lesions from two more areas, Chiang Mai in Thailand and Kuala Lumpur in Malaysia (Axéll, Bte Zain, and Siwamogstham 1990), although based on a much smaller sample and more selected material. The findings are summarized in table 27-1. It should be understood that several of the conditions may be painful or even precancerous. For example, leukoplakia has been recognized as a frequent precursor to oral cancer, and researchers in one study with an average observation period of 7.5 years showed that 17 percent of leukoplakias became malignant.

A chapter in this collection is devoted to cancer, but it should be mentioned here that the prevalence of *oral cancers* differs widely between different areas. In a survey of the literature, the reported incidence rates of oral cancer, including vermilion border of the lip, varied from 5 to 25 cases per 100,000 population in industrial countries and from 2 to 17 in developing countries (Andreasen and others 1986). Smoking tobacco and drinking alcohol are the major etiologic factors. Also, it should be observed that not only the stronger types of alcoholic drinks, like whisky and vodka, are associated with the disease but also wines and other less alcoholic drinks. Chewing tobacco with or without areca (betel) is carcinogenic.

Special oral health problems are associated with HIV infection. Pindborg (1989) proposed a classification for lesions that included a variety of fungal infections, bacterial and viral infections, neoplasms, neurological disturbances, and lesions of unknown cause. The tabulation is preliminary and revisions are foreseen. It is clear, however, that the oral cavity often displays symptoms of HIV infections, and some of the diseases that occur are very serious.

Malocclusions include, for example, crowding or spacing problems, overjet, deep or open bite, crossbite, and scissors bite. Several problems can result from malocclusion, such as

Table 27-1. Prevalence of Oral Soft Tissue Lesions in Chiang Mai, Kuala Lumpur, and Sweden

Lesion	Prevalence (percent)		
	Chiang Mai	Kuala Lumpur	Sweden
Infections			
Herpes labialis	0.9	0	3.1
History of herpes labialis	5.6	2.6	14.3
Intraoral herpetiform lesion	0.9	1.3	0.3
Pseudomembranous candidiasis	0	0.4	0.2
Angular cheilitis	0.9	0.9	3.8
Ulcers			
Recurrent aphthae	11.1	5.1	2.0
History of recurrent aphthae	37.2	21.9	15.7
Traumatic ulcer	13.2	12.4	4.3
Whitish lesions			
Leukoplakia	1.3	1.7	3.6
Preleukoplakia	1.7	1.7	6.4
Smoker's palate	3.4	3.4	1.1
Betel chewer's mucosa	0.4	1.3	0
Frictional lesion	3.8	5.2	5.5
Cheek and lip biting	1.7	5.6	5.1
Leukoedema	23.9	29.6	48.9
Lichen planus	3.8	2.1	1.9
Denture-related lesions			
Denture sore mouth	3.4	7.7	16.0
Flabby ridge	0	0.4	8.6
Denture hyperplasia	0.9	0	3.4
Tongue lesions			
Median rhomboid glossitis	1.3	1.3	1.4
Geographic tongue	5.1	6.4	8.5
Plicated tongue	3.4	5.2	6.5
Hairy tongue	0	0.9	0.6
Atrophy of tongue papillae	3.0	1.3	1.1
Pigmentation			
Melanin pigmentation	70.5	88.4	9.9
Amalgam tattoo	0.9	0.4	8.2
Tumors and tumorlike lesions			
Carcinoma	0	0.4	< 0.1
Papilloma	0.9	0	0.1
Hemangioma	2.1	1.7	0.1
Lipoma	0	0.4	0.1
Fibroepithelial polyp	1.7	3.9	3.3
Pyogenic granuloma	1.3	0.9	0.1
Mucocele	0.4	0.4	—

— Not available.

Source: Table based on study of 234 people in Chiang Mai, 233 in Kuala Lumpur (Axéll, Bte Zain, and Siwamogstham 1990), and 20,333 subjects in Sweden (Axéll 1976).

Table 27-2. Changes in Caries Prevalence in Twelve-Year-Olds, by Country

Country	Year	DMFT [a]	Year	DMFT [a]
Asia				
Bangladesh	1979	1.8	1990	3.5
China	1951	0.6	1985	0.7
French Polynesia	1977	10.5	1987	2.5–3.8
Indonesia	1973	0.7	1982	2.3
Myanmar	1977	0.8	1990	1.1
Philippines	1977	2.5	1982	5.5
Singapore	1970	2.9	1984	2.5
Thailand	1977	2.7	1989	1.5
Tonga	1966	0.7	1986	1.0
Industrial countries				
Belgium	1972	3.1	1988	3.1
Canada	1977	6.0	1987	4.3
Finland	1975	7.5	1991	1.2
Japan	1975	5.9	1987	4.9
New Zealand	1973	6.0	1989	2.4
Sweden	1937	7.8	1989	2.2
United Kingdom	1973	4.7	1983	3.1
United States	1965/67	4.0	1986/87	1.8
U.S.S.R.	1972	3.5	1986	3.0
Latin America and the Caribbean				
Argentina	1965	4.5	1987	3.4
Brazil	1976	8.6	1988	6.7
Cuba	1973	5.1	1984	3.9
Mexico	1972	2.7	1984	3.2
Middle East and North Africa				
Algeria	1974	1.9	1987	2.3
Israel	1966	2.4	1989	3.0
Jordan	1962	0.2	1991	1.7
Morocco	1970	2.6	1989	1.8
Syrian Arab Republic	1974	4.4	1989	1.7
Sub-Saharan Africa				
Central African Republic	1974	0.2	1986	4.1
Malawi	1978	0.8	1991	0.7
Sudan	1979	1.1	1984	2.1
Tanzania	1973	0.6	1989	1.0
Togo	1973	1.6	1986	0.3
Zaire	1970	1.0	1985	1.0
Zambia	1971	0.1	1982	2.3

a. DMFT: Number of decayed, missing, and filled teeth.
Source: WHO Global Oral Data Bank.

difficulties in jaw movements and temporomandibular joint disturbances. Speech and swallowing might be affected, and psychosocial problems may occur if aesthetic problems are apparent. In their study from the United States, Kelly and Harvey (1977) indicate that the majority of American children and adolescents have a malocclusion of some type. Actually, they showed that 75 percent of the youths, age twelve to seventeen years, had a deviation from the ideal situation and about 25 to 30 percent had a severe malocclusion. For these conditions, the treatment needs and demands vary among countries. The problem itself is an important factor, and it is compounded by the possibility of requiring specialist treatment, the cost of which is, of course, also an important factor.

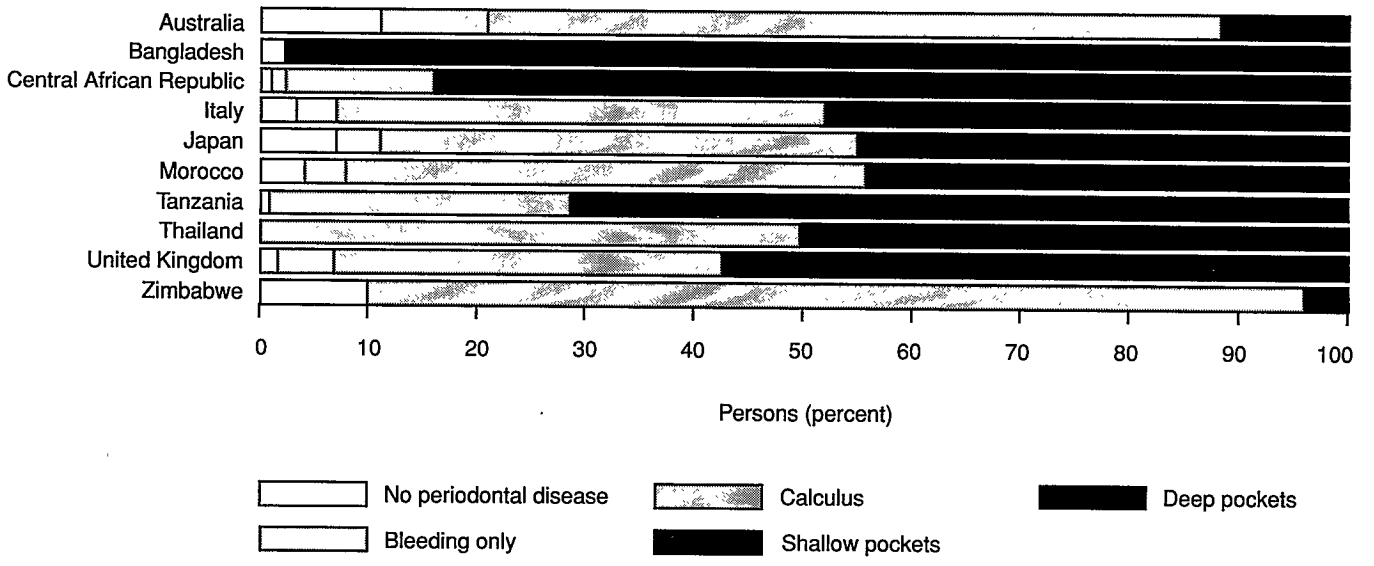
Disease Prevalence: Current Levels and Trends

Oral diseases can be measured by various indexes. The indexes may focus on the prevalence of the disease by cross-sectional studies, or the incidence, by longitudinal studies. For dental caries, a cross-sectional study will reveal lifetime caries, or the amount of caries since the first permanent tooth appeared in the mouth. Missing teeth pose special difficulties; a tooth may be missing because advanced caries required its extraction, but it may also be missing for other reasons, such as periodontitis, orthodontic reasons, or aesthetic reasons. It will be appreciated that age is an important factor to be taken into account when evaluating caries data—the older the age, the greater the risk of more damaged teeth. Thus, the caries index always shows higher individual values with age. When caries levels are compared for different populations, the same age groups must therefore be chosen.

Information regarding the prevalence of dental caries is overwhelming. It stretches from ancient times, as recorded by archaeological investigations of skulls, to the present, when, in some areas, all children are subjected to annual checkups, including x-rays, and data are fed continuously into computers so that even minor changes can be seen. To obtain comparable data, it is important that the same recording methods be used, and in this field, the Oral Health Unit at the World Health Organization (WHO) has prepared guidelines for oral health surveys, recommending indicator ages; recording forms are also produced. Since the early 1970s, a powerful instrument to monitor changes in oral health trends has been set up at WHO in Geneva: the Global Oral Data Bank. At present it contains files on more than 1,000 surveys, dating from 1937, with data on caries for 148 countries and on periodontal diseases for 103 countries. Each year global maps regarding caries and periodontal diseases are produced illustrating the latest information using comparable data. In table 27-2 we show examples of caries data from some countries.

Various indexes are also used to estimate the degree of gingival inflammation and periodontal disease. The WHO studies use the Community Periodontal Index of Treatment Needs (CPITN; see Barmes and Leous 1986; Pilot and others 1986). The index is based on three indicators: (a) presence or absence of gingival bleeding; (b) supra- or subgingival calculus; and (c) periodontal pockets, subdivided into shallow (4 to 5 millimeters) and deep pockets (6 millimeters and more). The mouth is divided into sextants and certain index teeth are registered for any of the indicators. The sextant will obtain a score from 0 (healthy) to 4 (≥ 6 millimeter pocket), and the highest score found on the index teeth is chosen for the sextant. The results for some countries are shown in figure 27-1. Johnson (1989) calculated that approximately 5 to 20 percent of most populations that have been adequately surveyed had destructive periodontitis of a "clinically significant" degree.

Figure 27-1. Observed Periodontal Conditions Measured by CPITN *at Age 35–44, Selected Countries*



Source: WHO Global Oral Data Bank.

The situation for dental caries has changed during the last decades of this century, as shown in table 27-2. A tremendous decrease in the prevalence of caries has occurred in several industrial countries, at least in younger age groups. Some developing countries, however, show the reverse trend. Some explanations for these facts are listed in table 27-3.

It is clear that a number of factors may have been instrumental in the decrease in caries in industrial countries. It is not possible, as yet, to grade the various factors, because the importance may vary from country to country and the importance of an individual factor is dependent on the original level of caries.

The information available as a whole may illustrate the situation. In historical times, the problem of caries was minor, worldwide. Exceptions can be found in certain populations, and some groups of people showed the presence of root surface caries. An increase was noted in restricted groups of populations when refined sugars were introduced. At the beginning it was mostly people from higher social classes who could afford these products who were affected. In many Western countries, a "caries explosion" started during the period between 1850 and 1900, when industrialization and new dietary habits arrived.

Demand appeared for oral health services, for professional extractions, and for the repair of damaged teeth. Dental schools were built, new instruments were developed, and new filling materials were progressively devised. A golden age for dentists began, brought about by a never-ending demand for oral health services. Eventually, it was realized that fillings, crowns, bridges, and the like did not last very long and that at least one-third of dental treatment involved replacing previous treatment. A growing demand for preventive measures became apparent and a number of methods were devised, resulting in a sudden decrease in caries and periodontitis. The demand for services is now on the decrease in highly industrialized countries. Dental schools face problems because of the reduced need for dentists, some being forced to close and others to reduce the intake of students.

Meanwhile, developing countries are turning to more Western food. Very often these countries have no, or very limited, resources for oral health treatment. Interest in prevention is understandably low, because oral health problems have, until recently, been more or less nonexistent. Caries is increasing, particularly in the cities, resulting in a growing demand for better dental services.

Patterns for the Years 2000 and 2015

The World Health Organization has defined a certain number of goals for oral health for the year 2000.

- Fifty percent of five- to six-year-olds will be caries free.
- The global average will be no more than three decayed, missing, or filled teeth at twelve years of age.
- Eighty-five percent of the population should retain all their teeth at age eighteen.
- A 50 percent reduction in present levels of toothlessness at age thirty-five through forty-four will be achieved.
- A twenty-five percent reduction in present levels of toothlessness at age sixty-five will be achieved.
- A data-based system for monitoring changes in oral health will be established.

Table 27-3. Current Trends in Caries Prevalence

Trend	*Intervention*	*Comments*
Decrease in industrial countries	Fluoride in toothpastes	Fluoride has been added since the 1950s; 80–95 percent of toothpastes contain fluoride. It is considered a major reason for the decrease.
	Water fluoridation	Fluoride content of drinking waters may be adjusted to optimal levels. Positive effects may be obtained even with local applications.
	Salt or milk fluoridation	Used in some countries.
	Fluoride tablets, topical application, rinsing, varnishes	Used in various school-based programs, as well as individually.
	Oral hygiene	Information, instruction, and supervised oral hygiene programs may have resulted in improved hygiene.
	Dietary advice	Mainly focused on reduction of sucrose. Total sugar consumption has not dramatically changed. Use of sugar substitutes has increased.
	Oral microflora changes	Temporary suppression through antibiotics. Possible effects on acid production through fluorides and other antimicrobial substances.
Increase in developing countries	Changes in diet	Westernization of diet

Source: Compiled by present authors.

For caries, one important goal is that the mean number of decayed, missing, or filled teeth should not exceed three at the age of twelve. Current trends seem to indicate that many Western countries have a good chance of reaching this goal (Pilot 1988). Other countries, such as Poland, have expressed doubts about the possibilities of reducing caries to that extent (Ja'nczuk 1989). Many developing countries have never exceeded that particular goal, but the crucial question remains: will the increase observed in some countries be halted or not?

The year 2000 is close, and for 2015, no goals have yet been set. Let us therefore present two "scenarios."

THE OPTIMISTIC SCENARIO. The ongoing trend toward a decrease in oral diseases in Western countries continues. New effective prophylactic agents are introduced, special programs for risk groups are designed, and oral diseases in the elderly are kept under control. The profession adjusts itself to the new situation. By agreement, many tasks are transferred from dentists to personnel with less costly education. The number of dentists decreases, but the profession aims at, and succeeds in, distributing the resources according to geographical needs. Although the number of dental schools is reduced, the resources for dental research are not. Politicians are also aware of the fact that oral diseases are not eliminated, just kept in check. Therefore, resources for continuous preventive methods remain intact.

In developing countries, the authorities realize that they have to choose one of two ways—either the expensive one used earlier by the Western countries or the immediate introduction of effective preventive programs. They choose the latter one and are successful in educating the people in the value of prevention before the diseases become prevalent. Traditional foods are retained as far as possible, and if between-meal snacks containing sucrose are introduced, they will come after the introduction of preventive programs. These programs have been worked out in collaboration with advanced research institutes in industrial countries. Knowledge has thereby been transferred and resources have been allocated to help introduce the programs.

THE PESSIMISTIC SCENARIO. To begin with, the decrease in prevalence of the diseases continues for some time. This is interpreted by the decisionmakers as the elimination of dental diseases. The interest of the individual, the profession, and the politicians in supporting preventive efforts decreases. Preventive programs in schools are reduced; some cities stop adding fluoride to drinking water. Development of new preventive methods are successful, but the research and development costs are high, resulting in high prices for the products; therefore, they are used only by a few.

The elderly population is increasing. They will have more teeth than before. Root surface caries cannot be kept under control. There is a shortage of personnel at homes for the elderly, and the care givers that remain show little interest in taking care of the teeth of their patients, particularly because the task has become increasingly difficult, owing to the fact that the "extra" teeth are situated more posterior than was the case earlier. Many extractions follow, but the elderly demand fixed teeth, and therefore treatments involving extremely expensive implants and bridges increase rapidly. Because the number of dental schools has been reduced, the number of staff (that is, the dental researchers) has also been reduced. At the beginning, endless discussions between the dentists, dental hygienists, nurses, and other supporting groups are held, finally leading to the withdrawal of the possibility for these groups to perform clinical work. All of a sudden, when it is realized that there are too few dentists, it becomes a problem to cover the less popular areas of the countries with professionals.

The consumption of Western type of food, including junk food, is rapidly increasing in developing countries. Starting in the cities, caries is increasing and the demand for restoration, not for prevention, is growing. Dental schools and dental clinics are being established to meet this demand. Preventive programs are launched, but because of the lack of resources, interest, and knowledge, the programs reach only a small proportion of the population. Also, the profession favors the reconstructive approach because it gives higher income and status. Dentists are gathering in and around the big cities, leaving extractions in the underprivileged population to be performed by less-qualified personnel. Advertisements for Western food and other products are flourishing, including cigarettes. In many developing countries, smoking is on the increase, resulting in more and more cases of oral cancer.

In both developing and industrial countries, HIV infections are spreading rapidly, and patients with oral manifestations are frequently seen in clinics. Resources have to be set aside for these patients and, because special, often time-consuming arrangements for infection control have to be made, these patients take more and more time to treat. Due to general environmental problems such as pollution, climatic change, drug abuse, and even war, smaller and smaller proportions of national budgets are being set aside for health purposes, in particular, for oral health.

The coming decades will be extremely important, because the decisions to be taken will influence oral health for many years to come. At the present time, it is possible to have some hope for a positive outcome. The pessimistic scenario, however, was very easy to imagine. Some questions to consider when trying to decide which scenario will come out on top are, for example, is it usual that decisions are made which favor the health of the total population? Is present knowledge about prevention being used properly? How many years does it take to introduce new ideas to an entire population? Will environmental and economic crises be solved? What are the resources for introduction of the negative factors in relation to the health-supporting activities?

All the facts mentioned in the two scenarios will probably happen, somewhere in the world. We will have various combinations of the pessimistic and optimistic scenarios. Some countries will be winners, some losers. The regular monitoring reports from the WHO Oral Data Bank will reflect the net outcome worldwide.

Economic Costs

A patient has a cavity that needs restoration. How much does it cost to get it filled? The directs costs involve time for drilling, filling, and polishing, plus the materials. Further costs include those of office space, dental equipment, salaries for personnel, office supplies, telephone, and so on. If the tooth had been more seriously damaged, perhaps a crown would have been necessary, which would have meant additional costs for impression materials, labor of technicians, gold, x-rays, transportation between dentist and technician, and so on. Other costs cover training personnel, running dental schools, dental supply depots, dental research and dental journals, patient time, traveling costs, and so on, plus administration of the dental programs within the government health divisions and departments. In different countries, the proportion of the total costs varies according to how much is finally charged to the patient and how much is paid through taxes. For this reason, comparisons between fees charged for a filling must be assessed with caution. In addition, trying to get the values in comparable monetary values is almost impossible, but here are some examples.

The fee for one occlusal surface filling in a molar of an adult patient would, in the United Kingdom, be about £5 (corresponding to about US$8), of which the patient would pay directly 75 percent, if the dentist is working within the National Health Service. In Sudan, the patient would have to pay about 12 Sudanese pounds, or about US$1 to $2, and in a Brazilian city, US$25 could be charged. The figures are easily misleading, however, and a WHO/FDI (World Health Organization/Fédération Dentaire Internationale) joint working group, JWG 9, proposed instead a relative value system, in which different treatments were related to a particular item, giving the value 100. The item chosen was a one-surface amalgam filling, in a first molar, including anesthesia and lining.

Data from the following countries are available: Austria, Denmark, Finland, France, Hong Kong, Japan, the Netherlands, and Sweden. The fee index indicates that the price for upper and lower dentures would be about twenty to ninety times more expensive than the filling. One porcelain or metal crown was estimated to cost seven to forty times more than the filling, and a simple extraction was estimated to cost from 33 to 148 percent of the fee for the filling.

Here is another way to illustrate the cost of treatment. In a provincial hospital in a district in Zimbabwe, 48 kilometers from the capital, Harare, a simple filling would cost Z$5.00, equivalent at that moment to about US$2.50. For the same amount of money, 1 to 2 kilograms of meat could be obtained, or two tubes of toothpaste, or 7 kilograms of brown sugar. Or, the patient could have traveled by bus to Harare, enjoying 100 pieces of candy during the trip. At a private clinic in the capital, the patient could be charged four to five times more for the filling.

Total costs for dentistry may be very low at present in some developing countries, where, in some cases, the total budget for health is just a few dollars per person per year. In industrial countries, dental costs may often reach about 10 percent of the health budget. This is the case in Switzerland, for example (6.5 million inhabitants), where total costs have been calculated at about 1.7 billion Swiss francs (SFr), corresponding to about SFr 400,000 per dental surgery (Meier 1988).[1] Ninety-four percent of these costs are paid by the patients, the remainder by the state. In Sweden (about 8.5 million inhabitants), the total cost for dental care was 6,505 million Swedish krona (Skr) in 1985, of which 44 percent was covered by the state, 25 percent by county councils, and 31 percent by patients. These are direct costs only and do not cover such expenses as

education of dental personnel or loss of working hours for the patients. Current direct dental costs per inhabitant of Sweden would amount to approximately US$125 per year.

For the purpose of comparison, it is interesting to study the costs for an advanced form of therapy, implants. This treatment is used for patients who do not have teeth in one or both jaws. In 1986, a thorough cost evaluation (Karlsson 1986) of such care, the Brånemark method, was made for ten patients who had received treatment in specialist clinics in a county of Sweden. The treatment involves the following procedures: after detailed examination, titanium fixtures are implanted in the patient's jaws by a surgical operation. After a healing period of three to six months, "distances" are applied, and after a further two weeks, bridges can be inserted, fixed to the distances. This procedure is followed by several checkups. Thus, the result is "fixed" teeth for a patient, for whom the previous alternative was removable dentures.

In the study referred to, Karlsson (1986) calculated direct costs (for treatment time for dental personnel and for equipment) and indirect costs (resources lost because of missing teeth, such as work problems, time, and travel for the patient). Furthermore, the author discussed calculation of costs of a more undefined character, such as the monetary value of the problem of having no teeth. Because of the great difficulties of obtaining such values, these costs were not included in the results. The results showed that the total cost for one jaw was about Skr 40,000 to 60,000 (about US$6,150 to $9,230). This cost is about seven times higher than for removable dentures, under similar conditions.

Certainly, these calculations are relevant only for this particular group of patients, and similar treatment in other countries would give other results because of varying costs for dentists' time, transportation, and so on. Still, the calculations illustrate the enormous costs that could follow if no preventive programs that protect against loss of teeth are implemented and if the population demands fixed teeth.

Elements of Preventive Strategy

The basic elements of a preventive strategy consist of identification of, and action against, the etiological factors for each oral disease. In table 27-4 we illustrate these elements for some diseases. As can be seen, information and motivation are important preventive methods for several conditions. The use of these methods, however, requires that the patient (population) follow certain rules. One definite advantage of a method such as water fluoridation is that people will benefit even if they are unable to follow advice because of sickness, failing interest, lack of education, and the like.

The elements of prevention must be presented within a system, and the industrial countries have developed more or less effective frameworks. In developing countries, this work is still in the beginning stages, and includes a strategy with primary, secondary, and tertiary prevention. One concept for primary oral health care was recently described by Jeboda and Eriksen (1989). They suggested these levels:

- Level 1. Prevention of onset of disease (prepathogenic), including integration of general and oral health; information, advice, control; diet and nutrition; general and oral hygiene; fluorides.
- Level 2. Prevention of further development of disease, including simple fillings; fissure sealing for high-risk patients; professional hygiene.
- Level 3. Relief of pain and debilitating consequences of disease, including emergency treatment, extractions, and medication; referral.

Cost and Effectiveness

An example from Switzerland may illustrate cost and effectiveness in an industrial country. The estimations have been made available by Dr. M. Büttner (personal communication, 1989). In the canton of Basel, 30.4 tooth surfaces per fifteen-year-old child had to be restored in 1961. The cost for these treatments was estimated at SFr 2.8 million per 1,500 children. In 1988, only 3.7 surfaces per child had to be restored, at a cost of SFr 0.3 million, thus a difference of SFr 2.5 million.

In 1962 a water fluoridation program was implemented in Basel, and in 1970 a school-based preventive dentistry program was introduced. During the past two decades, fluoridated toothpaste has become more and more prevalent in the marketplace, and approximately 90 percent of the population now uses such toothpaste. Seventy percent of the population uses fluoridated salt.

The school-based program, which actually starts when the children are three years of age and follows the children throughout secondary school, includes topical fluoride applications and oral hygiene instructions as well as dietary advice. Most tasks are performed by auxiliaries. The cost for this program is estimated at SFr 16 per child per year. Thus, for 1,500 children who participate in the program for ten years, the cost would be SFr 240,000. The cost for the fluoride used for water fluoridation and maintenance in Basel is now estimated to only SFr 0.5 per person per year.

Some further data on the effectiveness of the program can be mentioned: of the fifteen-year-old children leaving school in 1967, 0 percent had no caries. In 1988, 34 percent had no caries. For the same age group, fifteen teeth were affected, as a mean, in 1961, whereas only three teeth were affected in 1988.

It is not possible to estimate exactly how much of the caries reductions are due to the various components in the program. In countries without fluoridated water or salt, substantial reductions in caries have also been observed, if fluoridated toothpaste and school programs are used.

The Future of Prevention Technology

Can we expect new methods that will change, dramatically, the basis for preventive treatment of the oral diseases? Dental research tries to find new ways, in several directions. Intensive studies focus, for example, on plaque-inhibiting substances.

Table 27-4. Preventive Strategies for Oral Health

Condition	Cause	Action needed	Methods
Dental caries	Increased sugar intake	Reduce sugars	Information, recommendations; increase price of sugars, taxes; sugar substitutes
	Plaque present	Reduce plaque	Information and instruction; more effective tooth cleaning; flossing, toothpicks; professional tooth cleaning; less sugars in diet; fissure sealants; antimicrobial products
	High *mutans streptococci* levels	Reduce *mutans streptococci*	More effective tooth cleaning; less sugars in diet; antimicrobial varnish; chlorhexidine gels and rinses; vaccination
	Insufficient fluoride in relation to etiological factors	Increase fluorides	Water fluoridation; daily use of fluoride toothpastes; fluoride-containing drinks and foodstuffs; varnishes, rinsing programs; fluoride tablets, gels
	Reduced saliva secretion	Compensate	Find out reasons and take appropriate actions
Periodontal disease	Plaque present	Reduce plaque	Information and instruction; more effective tooth cleaning; flossing, toothpicks; antimicrobial products; professional tooth cleaning; scaling
	Specific pathogenic bacteria	Reduce bacteria	Antibiotics
Oral cancer and precancer	Increased risk factors, including tobacco, alcohol	Reduce risk factors	Information, motivation
AIDS-related symptoms	Risk behavior	Treatment and prevention	Information, motivation
Lip and palate clefts	Present from birth	Surgical treatment	Care in dental hospital
Fluorosis	High fluoride intake	Reduce intake	Defluoridation of drinking waters; identify other sources; information
Orthodontic problems	Genetic	Treatment	Care by specialized personnel for advanced cases
	Other dental diseases, caries, or periodontal disease	Prevention	Care by specialized personnel for advanced cases
Temporomandibular joint problems	Stress	Treatment and prevention	Individual treatment, information, clinical care
	Other dental diseases, caries, or periodontal disease	Prevention	Individual treatment, information, clinical care
Traumatic injuries	Sports	Treatment and supervision	Individual treatment, mouth guards

Source: Authors' compilation.

Such products could have an effect on the tooth surface, the saliva pellicle covering the teeth, or the oral bacteria. Several products seem to be promising. The products would be administered through mouth rinses, topical application, or tablets. Prices, number of applications, and long-term effects are as yet unknown, and it can be assumed that these products will first be used in industrial countries.

Whereas plaque-inhibiting substances act on most bacterial types forming the dental plaque, other substances try to find means of attacking the pathogenic bacteria. Most studies concern the mutans streptococci. Very promising results have been reported by Sandham and others (1988). They have found that a varnish, containing chlorhexidine, can eliminate the mutans streptococci in many patients. The use of this

varnish could be combined with methods which identify persons carrying large amounts of these bacteria. The system seems to be ready for large-scale clinical studies. It is important, however, to evaluate the effects on caries, not only on the bacteria.

Vaccination against dental caries has been discussed for decades, and vaccines that have good protective effects in animals have been produced. Hesitation to test these products on humans stems from concerns for safety. Because caries is not a deadly disease, not one single case of fatal side effect should be accepted. Suspicion of possible unwanted cross-reactions of certain caries vaccine preparations with human tissues has been substantiated, and, therefore, the first generation of these vaccines will probably not come into use. Genetic engineering, however, is making possible the development of new versions, in which antigens of the mutans streptococci are transferred into normal gut microorganisms. It is possible that such a vaccine will reduce the mutans levels on the teeth, with concomitant reduction of caries. Many years of research will still be needed, however, if effective vaccination is to be of use to developing countries.

Although fluorides have been investigated intensively for decades, new products can still be expected. For example, Ögaard and others (1988) have suggested that a hydrogen fluoride solution with low pH, resulting in calcium fluoride-formation on the teeth, could be very effective, and some pilot experiments have supported their hypothesis. More clinical experiments are necessary, however, to prove its usefulness under field conditions.

Dietary modifications through the use of sugar substitutes may be effective, but so far the products are, in general, comparatively expensive and present some side effects if consumed in large amounts. Industrial countries have more opportunity to use the products currently available. It is possible, however, that new products, or modifications of sucrose, will become available which will also be suitable for developing countries.

These few examples serve to illustrate the fact that new strategies may be devised, some within a fairly short time, but those particularly useful for developing countries may yet be years away. Still, that technology will change is now apparent; it will leave drilling and filling for more advanced technology, based on microbiology and chemistry. The examples, however, focus on caries and periodontal diseases. The spectrum of other oral diseases may become affected by the changes exemplified only to a certain degree. Rather, there may be a risk of increase in some conditions in developing countries, such as traumatic injuries from traffic accidents as traffic increases.

Expected Minimum Standards

For a developing country, it is reasonable to expect that the following standards be achieved:

- The population should receive information about the principal oral diseases, thus allowing the individual to avoid habits and products that increase the risk of disease, such as frequent intake of products that contain sugar. Of course, if sugar-rich products are necessary for survival, that would take precedence.
- If pain is present, possibilities for pain relief must exist.
- If there is any risk of caries occurring, or if caries is already present, a fluoride program should be implemented, and if toothpaste is used, it should contain fluoride. If toothpaste is too expensive, school-based fluoride programs should be started. For cities, water fluoridation can be considered, provided good technical management and safety can be guaranteed.
- Although heavy formation of dental calculus is common in certain populations in developing countries, it might be unrealistic to suggest services like professional removal of calculus for these populations at present. It should be possible, however, to introduce oral hygiene programs among children, which would place the next generation in a better position.
- Oral manifestations of cancers, or precancerous lesions, are common in some populations. These populations should be, or have a chance to be, inspected for early signs of such manifestations at the same time that acceptable services for treatment are built up. If pathogenic processes are diagnosed, it should be possible to obtain surgical or other types of treatment.
- Serious cleft syndromes in newborn babies are not common, but if present, they require advanced treatment. A referral center for these conditions should be available. Such a center should also be able to take care of severe fractures from accidents and other causes.
- If fluorosis is present to a disturbing extent, defluoridation should be performed, if at all possible.

As a basis for all their efforts, the authorities should have an oral health program which includes surveys and other data collection to clarify the distribution of oral diseases within the population and incidence of the diseases. The main "local" etiological factors for the diseases should be known. The effects of preventive programs already implemented should be monitored. Changes in diet should be observed, in particular, any increase in sugar, and sugar-rich snacks, between meals. National authorities should work toward the training of dental personnel and the development of appropriate technology. Those who select personnel should bear in mind geographical distribution. Goals can be formulated: all persons should be able to eat, drink, and talk without discomfort. In addition, the mouth and teeth should have an acceptable appearance.

Oral Health Personnel

Oral health services are expensive, as revealed earlier. Manpower and education account for three-quarters to four-fifths of these costs. Therefore, resource planning should aim at ensuring that both the quantity and type of oral health person-

nel are adequate. It is certain that savings are possible if less-educated personnel can be used. It is apparent that several functions mentioned above could be performed by personnel other than dentists. It is also clear, however, that certain conditions demand highly skilled personnel. What, then, would be the best strategy for a given situation and the best combination of personnel types?

One should not expect a simple answer to such a question because the basis for decisions differs so widely among countries. But the question has been studied by WHO, and a planning instrument has been drawn up. Using the Lotus computer program, the WHO method for estimating oral health personnel requirements provides a procedure for rapid calculation on the basis of data or estimates for:

- Oral disease levels
- Need for oral care and retreatment frequency
- Demand for care
- Average time per item of care
- Average hours worked

For any single level of disease one can alter the assumptions on the demand for care, on treatment strategies which are more or less interventive, on retreatment frequency, and on time allocations per item for time worked. Thus, one can have widely different estimates of personnel needs for a single oral health status. Also, overall personnel needs can be subdivided on the basis of use of dental professionals only, professionals and auxiliaries, and professionals and auxiliaries and primary health workers. In the latter case, especially, the numbers should read as full-time equivalents rather than simply head counts. Subclassification, on the basis of intervention, allows for an aggressive treatment service, for which a prime example is one in which every tooth recorded as carious would be filled, through a moderate service, to a noninterventive system which uses high-risk assessments to defer filling any tooth as long as some form of prevention, simple surface care, or even "wait and see," can substitute.

In table 27-5 we give an example of this type of exercise for three distinct levels of dental caries, each managed through a range of strategies from interventive to noninterventive and displayed in three main oral health personnel combinations. Clearly, great differences in economic and health consequences are embodied in these comparative figures, for example, from 665 oral health personnel per million for the situation that includes high caries prevalence and an interventive strategy to 95 per million for the situation that embodies low caries prevalence and a noninterventive strategy. Similarly, within one caries prevalence level the differences are considerable; for example, the interventive strategy in the high caries prevalence level calls for 665 dentists per million, whereas the noninterventive strategy for that same prevalence level requires only 175 dentists plus 50 auxiliaries plus 40 primary health workers if the three-level combination of personnel is used.

As large as these differences are, they can be even larger if one varies such items as demand for care, time per item, and hours worked. The figures in table 27-5 are based on a 2,000-hour year. If this is changed to a more likely 1,500-hour year, or even a 1,200-hour year, which is a reality in many countries and not even a minimum, the lowest and highest estimates of personnel needed per million become 130 and 890, respectively, for the 1,500-hour year and 160 and 1,110, respectively, for the 1,200-hour year.

The full versatility of the system extends to extrapolating observed trends in the oral health status and to entering data appropriate to the achievement of stated, measurable goals in the medium to long term. This system is already a powerful planning tool, and the WHO Oral Health Unit hopes to expand it further in the near future with more specific measurement of economic factors. The importance of the system is also reflected when the number of dentists in relation to the number of inhabitants in some countries is considered (table 27-6). Hypothetical cases have been taken from the list in table 27-6 to highlight contrasts based on actual situations for which assumptions which seem most appropriate have been made.

Applying the WHO method and assuming the partially interventive strategy, a 1,500-hour working year, and a stable caries level, we conclude that one dental operator is needed in the following countries for the populations indicated: Brazil,

Table 27-5. Oral Health Personnel Needed per Million Population

Level of caries	*Strategy*	*Dentists only*	*Dentists plus auxiliaries*	*Dentists plus auxiliaries plus primary health workers*
Low	Interventive	145	75+70	75+30+30
	Partially interventive	105	40+65	40+25+40
	Noninterventive	95	35+60	35+15+45
Moderate	Interventive	255	165+90	165+65+25
	Partially interventive	195	125+70	125+45+25
	Noninterventive	160	95+65	95+35+30
High	Interventive	665	465+200	465+170+30
	Partially interventive	365	245+120	245+85+35
	Noninterventive	265	175+90	175+50+40

Source: Oral Health Unit, WHO, Geneva. Calculations based on 2,000 hours worked per year.

Table 27-6. Dentists per 10,000 Population, by Country

Country	Dentists
Asia	
India	0.1
Indonesia	0.1
Mongolia	0.4
Sri Lanka	0.2
Thailand	0.3
Industrial countries	
Belgium	6.1
Canada	4.9
Denmark	8.8
Finland	9.3
France	7.2
Germany	5.7
Italy	0.6
Netherlands	4.9
Sweden	11.0
United Kingdom	3.1
United States	5.9
Latin America and the Caribbean	
Argentina	2.2
Bolivia	0.6
Brazil	1.3
Colombia	3.6
Costa Rica	3.1
Chile	2.6
Uruguay	7.7
Middle East and North America	
Algeria	1.2
Jordan	2.4
Iran	0.5
Israel	7.1
Oman	0.6
Pakistan	0.1
Saudi Arabia	1.0
Yemen, Rep. of	0.0[a]
Sub-Saharan Africa	
Kenya	0.1
Mali	0.0[b]
Senegal	0.1
Sierra Leone	0.1
Togo	0.0[c]

a. In Democratic Republic of Yemen, only eighteen dentists in country.
b. Only fifteen dentists in country.
c. Only five dentists in country.
Source: World Health Statistics 1988.

2,990; Costa Rica, 5,488; Germany, 2,941; India, 5,696; Jordan, 8,036; Pakistan, 4,036; Sierra Leone, 10,976; Sweden, 2,601; the United Kingdom, 2,616.

Priorities for Resource Allocation

We believe resources in developing countries should be allocated to the following:

- An effective primary oral health organization for prevention and care. If possible, the activities should be combined with other health services or school-based programs.
- Referral centers as mentioned above. Also, developing countries are in need of some highly trained experts in various fields.
- Appropriate technology. It is important that equipment, materials, and methods work under field conditions. There are numerous examples of sophisticated and expensive dental units that are not operating in developing countries.
- Resources for oral health planning, preventive programs, and education. They include surveys, epidemiological studies, and the establishment of national or local registries, with efficient use of informatics and electronics.

We do not think that the present budgets for oral health in most developing countries are sufficient for the addition or enhancement of these items. New resources are necessary, but the many demands already present, as well as those expected in the near future, urgently need to be met.

Priorities for Operational Research

Many important questions and problems for oral health need attention. The list below illustrates some of them as seen from a global standpoint. Another order of priority may very well be chosen locally, which is why the list should not, by all means, be regarded as the universal truth.

- *Prevalence and incidence of oral diseases*. Epidemiological investigations should be performed regularly and records analyzed to monitor the oral health situation. They should, of course, include caries and periodontal disease, but it is important that they be extended to cover also the more common discomforting, premalignant or malignant oral diseases. Children and representative samples of indicator ages among the elderly should be included.
- *Etiological factors*. Concomitant with epidemiological surveys, one should try to identify the main factors causing disease in the population under investigation. Studies should be performed aimed at finding effective means of reducing such factors or risk behaviors.
- *Treatment needs*. Improved methods and tools to evaluate treatment needs and demand for oral care are necessary. The methods should include an attempt to determine the total needs of the population, taking into consideration also the less prevalent diseases.
- *Preventive programs*. A variety of preventive programs should be installed and new strategies should be tested. The possibilities of selecting risk groups should be further investigated, and various combinations of oral health personnel tested. In particular, it is important to establish the effect of primary health care workers during longitudinal studies.

Also, collaboration with nondental personnel within prevention needs further study.

- *Toothpaste and other oral health products*. It is believed that fluoride toothpaste and other fluoride-containing products have been of great importance in decreasing the prevalence of caries in industrial countries. The use of such products in developing countries should be promoted, but the outcome of such activities is also dependent on the price of the products. New products, more afforable than those produced today, must become available.
- *Transfer of knowledge*. The results of various oral health projects must be readily communicated so that good ideas can be picked up quickly by other countries or communities. Research should advise on improved methods to transfer knowledge and skills to developing countries. In particular, the possibilities offered by new technologies should be explored.

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1. A billion is 1,000 million.

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