WHO Expert Committee on Recent Advances in Oral Health

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1. Introduction

The WHO Expert Committee on Recent Advances in Oral Health met in Geneva from 3 to 9 December 1991. Dr J. Rochon, Director, Division of Health Protection and Promotion, opened the meeting on behalf of the Director-General. Reflecting on the history of oral health in WHO and the changing needs of oral health in general, Dr Rochon expressed appreciation of the way in which the Oral Health Programme had addressed all the principal elements necessary for a balanced strategy of improvement.

During the past few decades, WHO Technical Reports have guided oral health authorities in the fields of epidemiology, education, services, health education, and disease prevention (1–14). Special attention has been given to the highly prevalent problems of dental caries and periodontal diseases, to development of preventive strategies, to alternative teaching and service structures, to rational equipping and provision of care and training facilities, and to better reporting, measuring, and monitoring of the prevailing and changing situations. All of this work has benefited from a data-based approach, particularly the Global Oral Data Bank, established in 1969, which summarizes epidemiological data collected in Member States using a standard WHO methodology. This provides both a means of assessing progress and an early warning of the need to change strategies.

Dramatic improvements in scientific knowledge and technology in oral health mean that the potential now exists to eliminate the major disease — dental caries — almost totally. It also seems possible that the periodontal diseases, which remain prevalent, will soon follow the path of caries. These rapid, but steady, improvements have long pointed to the need for change within the profession, as the very essence of oral health care is transformed. However, the oral health profession and its partners in other health disciplines have been reluctant to modify either the educational process or the scope of practice, and thus find themselves beyond the crossroads: the process of change is already well advanced, yet future strategies remain to be fully defined. The profession also faces changing demographic patterns and a technological explosion, which combine to create bewilderment rather than confident progress.

It is this dilemma that led to the convening of an Expert Committee to examine recent advances and consider progress that can reasonably be expected in the near future, to guide WHO and, through the Organization, the health professions in making full use of the new technologies and strategies for better health.

The Committee’s terms of reference were thus:

- to consider advances in the fields of prevention, diagnosis, treatment, and computerization within the oral health profession;
- to advise on which measures should be implemented now and which after further development, and to identify areas in which more research is urgently needed;
• to examine the polarity that has developed in oral health between tissue-invasive or other high-technology interventions on the one hand and preventive, control, and self-care strategies on the other; and
• to give guidance on the growing need for integration of many activities with different areas of the health profession and with other sectors in the search for broader health strategies and involvement.

2. **Advances in the prevention of oral diseases**

Over the past several decades, there has been a gradual shift in focus from treatment of oral diseases to prevention. The eventual goal of virtually eliminating the two main oral diseases now appears to be not only reasonable but also attainable for a large majority in most populations. In no other health discipline, perhaps, has the impact of the preventive approach been so remarkable. Moreover, oral health research continues to yield a rich harvest of preventive options, from vaccines and antimicrobials to the potential for genetic manipulation of oral bacteria.

Altered lifestyles and an understanding of risk behaviours play a major role in the prevention of a wide range of oral diseases and conditions. Throughout the world the oral health profession has generally espoused and promoted a preventive philosophy that extends well beyond oral conditions, and this is to be encouraged and expanded. It has every justification for recommending to patients the avoidance of tobacco, moderation in the use of alcohol, adequate levels of exercise, social interaction, and sound dietary and nutritional practices, even though these behaviours may not all have clearly defined effects on oral health. Prevention and health care are ultimately issues that affect the quality of life: by promoting healthy lifestyles, oral health professionals can continue to make significant contributions to both general and oral health.

2.1 **Dental caries**

Although bacteria on the teeth are the direct cause of dental caries, a large number of microbiological, environmental, and host factors interact to determine whether or not an individual will be affected by this disease and, if affected, how and to what extent. For this reason, dental caries is considered to be a multifactorial disease. Caries is believed to be the same disease throughout the world, yet the impact of various etiological factors can be quite different in different individuals and in different parts of the world. It is this interplay of factors that gives rise to the observed variations in prevalence and patterns of caries worldwide.

The multifactorial nature of caries allows scope for a number of different approaches to prevention of the disease. Successful modification of any of the necessary conditions for caries can reduce or eliminate the disease in the affected individual. In practical terms, measures to prevent or reduce caries may have to be tailored to the etiological factors that are most amenable to change in any particular situation. It should also be
recognized that certain etiological factors have vastly different consequences, depending on the total mix of factors. For example, the consequence of a diet high in sucrose is quite different for a person who is frequently exposed to fluorides than for someone who has very little exposure.

While the exact mechanisms of action of many of the preventive approaches remain poorly understood, it is clear that current knowledge is sufficient to control caries, if not to eliminate it. It is not unprecedented in many areas of health care for highly effective preventive measures to be implemented well before the causative mechanism of a disease is fully understood. The full and appropriate application of the methods that are available to prevent caries presents a special challenge to oral health professionals.

2.1.1 Fluoride

Since the first half of this century, when scientists discovered that fluoride helps to protect teeth from dental decay, most of the work in caries prevention has been based on some type of fluoride use, and most of the success in reducing the prevalence of dental caries has been attributed to its use. Recent reports from both Australia and the United States of America have reconfirmed the safety and efficacy of fluoride in preventing dental caries (15, 16). The use of fluorides in various forms thus remains the cornerstone of most caries prevention programmes.

In the past few years, a better understanding of the mechanism of caries has led to an appreciation of the importance of fluorides in the remineralization process. The present concept of the cariostatic mechanism of fluoride, which is still under study, involves a reservoir of fluoride that is maintained in the oral environment for extensive periods of time, and provides free fluoride during decreases in the pH of the dental plaque. This reservoir is maintained by daily exposure to sources of fluoride, including fluoridated water and toothpaste, and release of the fluoride enhances remineralization. Epidemiological studies have shown that fluoride also aids in the prevention of root surface caries, which provides further evidence of its great value for people of all ages.

Fluoride also acts to prevent caries by reducing acid production by plaque bacteria. There is no evidence that fluorides at therapeutic levels reduce the amount of plaque present; however, fluoride used on a regular basis becomes concentrated in dental plaque, and appears to interfere with enzymes used by the bacteria in metabolizing sugars. Moreover, mixed with saliva and plaque, the fluoride ion in solution around the teeth appears to inhibit the uptake of sugar by plaque bacteria, depriving them of their major nutrient for acid production.

Water, salt, and milk are highly cost-effective vehicles for fluoride, and their fluoridation provides substantial protection against caries, even
where other sources of topical fluoride are in widespread use. Efforts to implement this type of fluoridation as a community health measure should continue wherever it is technically and politically feasible.

Fluoridated toothpaste is one of the most important delivery systems for fluoride, but cost remains a barrier to its widespread use in many places. Unfortunately, these are often places where water fluoridation is impossible because central water systems do not exist, or where local infrastructure is insufficiently organized to permit reliable community fluoridation measures. For much of the world, therefore, the development of affordable, fluoride-containing toothpastes or comparable products is imperative. Where special needs exist, other fluoride products, such as rinses, gels, and tablets, are available for both home use and professional application. Particular care is needed in their use, however, especially in the case of ingested forms of fluorides: ingestion of excessive amounts of fluoride by children during the time of tooth formation can induce fluorosis.

Other, newer vehicles for fluoride are now available, including fluoride-releasing sealants and restorative materials. More recently, fluoride pellets have been developed that can be bonded to a posterior tooth and allow a slow, continuous release of fluoride into the oral environment.

While the overwhelming value of fluoride in caries prevention is universally acknowledged, there are some locations where the levels of naturally occurring fluoride are far in excess of recommended levels. The United States of America has set a limit of 4 mg/litre (ppm) as the maximum allowable level in drinking-water and recommends a level of 0.7 to 1.2 mg/litre; lower levels, however, may be more appropriate in some other parts of the world. Inexpensive methods are available to defluoridate small amounts of water, but there is a great need for inexpensive methods for use with large volumes of water at the community level.

Information on the amounts and types of fluorides from all sources and their bioavailability is incomplete but would be of immense value in making recommendations for parts of the world where climates and dietary patterns are quite different from those in which most water fluoridation now takes place.

2.1.2 Sealants

The use of dental sealants is an effective way to prevent pit and fissure caries. Greater education regarding the value of sealants is necessary – for both oral health professionals and the general public – to increase the use of and the demand for this important preventive measure. One of the greatest barriers to increased use, however, is the fact that successful placement and retention of sealants are highly dependent on technique and the availability of appropriate equipment, including air and water spray and adequate suction. Without these, widespread sealant application is
impractical. Research must therefore be encouraged to develop a less technique-sensitive sealant material. The use of sealants by auxiliaries or primary health care workers in schools and similar settings would then become feasible.

Careful use of selection criteria, both for patients and for the teeth to be sealed, should also be encouraged. In populations with very low caries prevalence, and in individuals who are at low risk of caries formation, it is not cost-effective to apply sealants to all posterior teeth. Frequent monitoring of this aspect of preventive care is essential because of the continuing changes in caries levels in many parts of the world.

2.1.3 **Saliva**

Saliva is rich in calcium and phosphates, facilitating remineralization of early carious lesions. The development of *in vitro* models of demineralization and remineralization has greatly enhanced understanding of the mechanisms involved in these processes. These studies have been aided by the development of microanalytical techniques that enable detection of chemicals in very small samples of saliva. There is evidence that remineralization is associated with an increase in the size of enamel crystals and a consequent increase in resistance to caries, which is an additional benefit of the process. Remineralization as an approach to the treatment of early carious lesions should therefore be encouraged. The buffering capacity of saliva is also an important factor in caries resistance.

2.1.4 **Artificial salivas**

Recognition of the role of saliva in protecting and maintaining oral health through a variety of immune and nonimmune defence mechanisms has spurred research to develop artificial salivas, particularly since a number of drugs and systemic conditions have negative effects on salivary function. Many of these artificial products are useful in preventing rampant decay and other oral complications in patients with Sjögren syndrome and other diseases that affect the salivary glands, and in patients who develop xerostomia as a side-effect of drug or radiation therapy.

2.1.5 **Diet**

Technological advances in the study of the caries-promoting properties of food have provided new insights into the role of specific foods in the caries process.

The contribution of sucrose to the implantation, colonization, and metabolic activities of cariogenic bacteria has been clearly established, and has led to the search for sucrose substitutes. A number of caloric and non-caloric sweeteners have been identified and their non-cariogenic and anticariogenic properties evaluated. Palatinose is an example of such a caloric sweetener; it has the advantage of being an isomeric form of sucrose, yet appears to be non-cariogenic. This product is currently
undergoing testing in humans. However, several of the alternative sweeteners, including palatinose, are more expensive than sucrose at present.

Considering the extensive use of sugar substitutes in foods such as carbonated beverages and snack foods, identification and evaluation of their properties are of major importance. Non-caloric sweeteners (aspartame, cyclamate, saccharin) are not metabolized to acids by oral microorganisms; however, their taste and lack of stability are disadvantages, and many countries regard these products as toxicologically suspect. Sugar alcohols (sorbitol, xylitol, maltitol, mannitol), which are caloric sweeteners, have very low cariogenic potential; it has even been suggested that xylitol has anticariogenic properties. These sweeteners are used in "sugar-free" chewing-gums, toothpastes, medicines, and food products. Their use in medications is particularly appropriate: the high levels of sucrose in some preparations can have devastating effects when long-term drug therapy is required.

There are limitations, however, to the wider use of these sweeteners, because they may have undesirable gastrointestinal effects and effects on the electrolyte balance (mannitol in small quantities is used therapeutically to treat brain oedema). Other non-sucrose sugars (high-fructose corn syrup, invert sugar, glucose, fructose) are used more frequently, and may be somewhat less cariogenic than sucrose.

2.1.6 Antimicrobials

Infants acquire the bacteria that colonize the oral cavity and digestive tract after birth, usually through normal handling by their mothers or other care-givers. Sampling of the foods fed to infants, and other activities involving contact with saliva can transmit cariogenic bacteria. Investigators have shown that it is possible to interfere with the process of transmission of mutans streptococci by treating mothers and other close family members with antimicrobial mouthwashes. Chlorhexidine, for example, can not only prevent transmission of caries bacteria, but also effectively lower the risk of caries in individuals who already harbour high levels of cariogenic bacteria. Tooth varnishes that release chlorhexidine have recently been produced, and are now being tested in clinical trials. It may well be possible to apply these varnishes to pits and fissures in circumstances where the more sophisticated equipment necessary for placement of conventional sealants is unavailable.

2.1.7 Modifying molecules

The processes by which the normal bacterial flora become established in the mouth are being studied at the molecular level with a view to preventing the formation of plaque. Bacteria have been found to attach to teeth and other host tissues in a selective manner, using proteinaceous components called "adhesins". These adhesins are located on the bacterial surface, and bind stereochemically to complementary receptors on the tissue surface.
Research in this area may lead to the development of anti-attachment systems that would prevent pathogenic bacteria from colonizing the teeth and supporting tissues.

In other research involving genetic manipulation, researchers are developing replacements for pathogens in the mouth. Success in this area will depend on the ability of the mutant forms to compete successfully with the pathogenic bacteria in binding to and colonizing the oral tissues.

2.1.8 **Immunization**

An improved understanding of the genetics of oral bacteria is also leading to new approaches to the development of safe and effective oral vaccines. For instance, virulence factors have been identified on the surface of mutans streptococci, and the genes coding for these proteins have been cloned and introduced into a harmless strain of bacteria that normally inhabits the intestine. It is hoped that these recombinant bacteria may be used as a vaccine. Once swallowed, the bacteria would become established in the intestine; activated lymph cells would then generate anticaries antibodies which would be released in the mouth via the salivary secretions.

A vaccine may well be the method of choice for preventing caries in individuals at high risk and among populations who lack access to other preventive measures. While no usable vaccine has yet been developed, much progress has been made in research, notably in the areas of passive immunization and the use of synthetic antigens that may reduce the unwanted side-effects of earlier vaccines. The possibility of creating a polyvalent vaccine – effective against caries, as well as measles, poliomyelitis and other serious infections – is under consideration.

2.1.9 **Risk assessment**

Biological and epidemiological advances are enabling the identification of patients who are at high risk of developing disease; this will ultimately allow the targeting of preventive efforts towards those who are most in need. Progress in this area will become more important as the level of caries decreases in many populations.

Evaluation of any single etiological factor does not permit the risk of caries to be assessed for an individual patient, but factors can be identified that indicate a higher risk of disease for a particular group of people. For example, people with high counts of mutans streptococci or lactobacilli, high sucrose consumption, xerostomia, or poor levels of oral hygiene are at higher risk than people who do not share these characteristics. Preventive programmes tailored to groups selected on the basis of one or more of these characteristics have already been implemented in some countries. Further improvements in such programmes and their wider implementation in various situations are challenges for the future.
2.2 Periodontal diseases

2.2.1 Gingivitis

While caries has been linked strongly with only a very few organisms, the development of gingivitis appears to be caused by nonspecific bacterial plaque flora, which changes over time from predominately Gram-positive to more Gram-negative. Gingivitis does not necessarily develop into periodontitis — there is ample evidence that there can be long-standing gingivitis without a transition to periodontitis. However, periodontitis is always preceded by gingivitis. At present, therefore, the prevention of periodontitis is based on prevention of gingivitis. The basis of prevention is good, regular, mechanical removal of plaque, plus antimicrobial and antiseptic mouthwashes if necessary. Where oral hygiene levels are generally high, fewer than 10% of the adult population develop advanced periodontal destruction. Epidemiological data on periodontal conditions in older age cohorts are difficult to interpret because of tooth loss, but the severity and extent of periodontal disease generally increase with age. For patients who are unable to manage mechanical plaque removal on their own, antibacterial agents have proved to be useful adjuncts for plaque control.

At present, there are no biological markers available to identify individuals who are likely to be at high risk for future periodontal destruction. However, people who already have periodontal attachment loss are more prone to further loss, and this underlines the need for regular monitoring of periodontal conditions.

2.2.2 Microbiology

There is no single organism that is pathognomonic of a change from gingivitis to adult periodontitis. However, several species (e.g. Porphyromonas gingivalis, Prevotella intermedia, Eikenella corrodens, Wolinella recta, Treponema denticola, and Capnocytophaga species) are present in various combinations in patients with adult periodontitis. The association between a Gram-negative anaerobic microflora and periodontitis has been extensively demonstrated, and elimination and control of this flora will reduce the risk of periodontitis.

2.2.3 Risk factors

All infections — periodontitis included — represent a balance between invasive and protective factors, and prevention of the periodontal diseases must therefore look at host resistance factors as well as microorganisms. Many reports have confirmed that tobacco use is a risk factor in periodontal destruction. It is also clear that general health problems (e.g. diabetes, human immunodeficiency virus (HIV) infection, illnesses and therapies that cause xerostomia) have profound influences on periodontal health, and that stressful life events may play some role.
2.2.4 Oral hygiene

Most gingivitis, and therefore most periodontitis, can be prevented by optimal oral hygiene. The optimal level of oral hygiene, however, will vary from individual to individual and, over time, within the same individual. A large proportion of most populations have only minor signs and symptoms of destructive periodontitis, and the disease can be managed by self-care and an appropriate lifestyle. As no reliable predictors of advancing periodontal destruction have yet been developed, good oral hygiene aimed at controlling the initial lesion should be stressed early in life.

Toothbrushes or chew sticks (miswaki) can be effective mechanical means of removing plaque. For both, instruction is necessary to ensure that they are used properly, to remove plaque effectively without traumatizing the oral tissues.

2.2.5 Antimicrobials

Antiplaque, anticalculus, and antigingivitis agents are now available as additions to toothpaste. Development of these materials should be encouraged, and they should be evaluated for both efficacy and safety. If the materials are compatible, these agents should be combined in a single paste, together with fluoride. Should such an approach prove to be successful, it could significantly reduce the prevalence of periodontal diseases.

2.3 Oral cancer

Oral cancer is a major concern because of the risk to the patient of severe disability and even death. Its prevalence differs widely among different populations: annual incidence rates vary from 2-4 cases per 100,000 population in some industrialized countries to as many as 25 cases per 100,000 population in southern Asia. Similarly, the incidence of oral cancers as a proportion of all cancers is highly variable: in certain societies that practise multiple tobacco use (chewing and smoking), the disease is the second most common form of cancer.

It is clearly important to identify precancerous lesions and conditions as early as possible. They are well classified, and clear-cut clinical definitions are available for lesions such as leukoplakia and erythroplakia. Precancerous conditions include sideropenic dysphagia, submucous fibrosis, lichen planus, and candidial infections.

Tobacco has been identified as the most important risk factor in the development of oral cancer and precancer. Its carcinogenic role varies widely in different settings, and is related to the type of tobacco product, the manner in which it is used, and its use in combination with other substances. Tobacco use combined with excessive use of alcohol may increase the risk still further, although the etiological role of alcohol alone in oral cancer has been difficult to study because alcohol use is so closely associated with tobacco use. Nutritional factors, such as deficiency of
iron and vitamins, have also been implicated in the process of oral carcinogenesis.

Some *Candida* biotypes have recently been shown to catalyse the formation of nitrosamines in leukoplakias. Viruses such as the human papilloma virus may carry oncogenic potential, although their role in oral carcinogenesis has not been definitely established. Herpes simplex virus type 1 has also been considered as an etiological factor. Obviously, much remains to be learned regarding the role of infection in the malignant transformation of cells in humans.

According to available data, about 3-6% of precancerous lesions become malignant over a 10-year period. Predictive markers of transformation are being studied, and promising results have been obtained using flow cytometry. Nevertheless, the clinical surveillance of these lesions remains highly important. Oral health personnel can fulfil a critical role in this. They should take advantage of routine oral health consultations to make complete examinations of a patient's head and neck, thus facilitating the diagnosis and management of precancerous conditions and the detection of any early malignancy. A thorough knowledge of the clinical appearance of precancerous lesions and early cancer is obviously necessary; prompt identification of lesions and referral of patients to specialists will be of the utmost importance in avoiding treatment delays and improving prognosis. Essential preventive activities include informing patients of known risk factors such as alcohol and tobacco use, and encouraging them to participate in cessation programmes. Attempts should also be made to treat and eradicate infections such as candidiasis, not only to relieve the discomfort of the infection itself, but also because of its probable role in carcinogenesis.

3. **Diagnosis and treatment of oral diseases**

This section describes a wide variety of options that are available to diagnose and treat oral diseases. It does not advocate application of the entire range in all populations; in some settings, only some of the options may be relevant at present. The basic principles, however, are universally applicable. In all settings, the goal is to prevent or arrest disease by any means, to reduce the need for treatment, and to provide care of high quality when treatment becomes necessary.

3.1 **Dental caries**

In the past, diagnosis of dental caries involved the use of a mirror, an explorer, and perhaps bite-wing radiographs. “Tugback”, or a feeling of resistance when the explorer was removed from the tooth surface, led to an almost unquestioned diagnosis of caries. Treatment, if not requiring extraction of the tooth, was synonymous with removing the affected tooth substance and replacing it with a filling material. Adherence to Black's
strict rules for the preparation of cavities for retention of the restorative material, avoidance of fractures of the filling, and "extension for prevention" (17) necessitated considerable loss of tooth substance beyond the actual caries lesion.

The modern approach to diagnosis and treatment, based on a series of important advances, differs from Black’s rules in almost all respects. The diagnostic process does not focus only on the presence of lesions, but is expanded to include identification of factors that lead to the formation of lesions. This approach therefore makes a distinction between the caries lesion and the caries disease, and comprises several important stages:

- clinical and radiological examination to detect early lesions or cavities;
- evaluation of factors that have resulted in the formation of the cavities (diagnosis of caries disease);
- control of identified etiological factors;
- treatment of caries lesions; and,
- formulation of a maintenance programme.

A simple but important advance in the routine clinical examination is the reduced dependence on the explorer and tactile impressions. Studies have shown that, at least for some populations, visual examination may be as effective as an explorer in diagnosing caries lesions and confirming the need for treatment. It has also been demonstrated that excessive force and improper use of the explorer can damage enamel, leading to cavitation in an incipient subsurface caries lesion (18). Future diagnosis of caries may be improved by the use of subtraction radiography or lasers; at present, however, these methods are largely confined to research settings.

In the past, the principal tool for evaluation of etiological factors has been the patient’s dental history, including a dietary record and an assessment of oral hygiene. This record does provide some basic information; however, a number of practical tests are now available that greatly increase the ability of the practising clinician to assess risk factors. The levels of mutans streptococci and lactobacilli, and the secretion rate and buffering capacity of saliva are among the factors that can now be evaluated reliably. Tests such as these make it easier to define the risk profile of the individual and to establish an appropriate treatment programme.

Treatment of caries as a disease thus focuses on attempts to improve the patient’s risk profile. One way to accomplish this is to reduce the effects of identified etiological agents, and several of the procedures for prevention of caries, discussed in section 2.1, are also valuable in this regard. Particular advances have been made in reducing the number of mutans streptococci on the teeth. Chlorhexidine, for example, is already established as an effective agent, and is available in various forms – as a gel, a rinsing solution, or a varnish.

Strengthening the patient’s resistance to collective attack factors will also improve the risk profile; the use of fluoride is the most important element in this approach.
The possibility of identifying and eliminating risk factors has a significant impact on the practice of restorative dentistry. With a successful programme to reduce the effects of etiological agents and increase host resistance, a caries lesion in its early stage need never become a cavity. Moreover, once cavitation is established, a much more conservative, non-invasive approach can be taken, with the result that a significant quantity of tooth substance is saved. The new approach to treatment of the caries lesion can therefore be outlined as follows:

- Incipient lesion
  - remineralization, using topical fluoride therapy
  - counselling on dietary and other risk factors.
- Initial cavitation
  - application of sealant
  - restoration with preventive materials, after minimal excavation and preparation with hand or rotating instruments, if necessary.
- Moderately sized lesion
  - restoration, conserving maximum amount of tooth substance.
- Deep lesion
  - restoration, conserving maximum amount of tooth substance
  - endodontic therapy, if necessary.

This new approach can also be applied to retreatment using the same steps and repairing physical defects only if symptoms are evident in the teeth or supporting tissue.

3.1.1 Biomaterials

The new approach to treatment of caries is further enhanced by the revolution in biomaterials, which has produced a variety of new materials capable of adhering to the tooth substance. Indeed, development of these novel materials has blurred the distinction between prevention and restoration. For example, in patients with regular access to care, sealant application can now be delayed until the detection of an initial caries lesion. Furthermore, “preventive restorations” are now available, which are essentially filled resin sealants used in the treatment of lesions with early cavitation.

For larger cavities, glass ionomers and composites have become viable alternatives to amalgam in many cases, because of their advantages in tooth conservation, their aesthetic appearance, and their caries-preventive or caries-arresting properties. Some of these materials release fluoride, which helps to reduce the risk of secondary caries. The combination of smaller cavity preparations and reduced risk of secondary caries leads in turn to a reduced need for the replacement of fillings, with ever-larger restorations.

These new materials and approaches to treatment are also very valuable for use in settings that lack “traditional” dental operating equipment.
Smaller cavity preparations can be made with hand instruments, and various preventive and adhesive restorative materials can be used. For example, even moderately sized lesions can be excavated with hand instruments and filled with glass ionomers.

In spite of the progress in prevention and in less invasive restorative approaches, large restorations will continue to be required in all parts of the world. Fortunately, advances have also been made in procedures at this more complex end of the restorative spectrum, of which the most prominent example is computer-assisted design/computer-assisted manufacture (CAD/CAM) technology. CAD/CAM reduces the time and effort necessary for the fabrication of inlays, and progress is being made towards the fabrication of more extensive fixed prostheses. The technology is currently used on only a small scale but, with further advances, may prove useful, and even cost-effective, in any setting: the initial cost of the CAD/CAM unit may be offset by a reduction in the resources devoted to dental laboratories and technicians, and the achievement of more consistent quality.

Endodontic care has been very important in enabling teeth to be retained. To optimize its effectiveness, however, consideration should be given to using more conservative approaches to pulp treatment. Generally, apical fillings are being used less. Better understanding of the mechanisms of dentine permeability, and development of materials that seal dentine will reduce the need for pulp care. Identification of the processes underlying pulp inflammation and repair may lead to new treatments for pulpal disease. Clarifying the neuro-attractant and neurotropic properties of the pulp should lead to better understanding of the mechanisms controlling development and growth of the dentine/pulp complex.

As caries levels continue to decline, there will be fewer deep lesions, fewer pulp inflammations, and thus progressively less need for endodontic therapy. A number of promising approaches to better diagnosis and care of the pulpal tissues have been identified.

The laser Doppler flowmeter, because of its ability to measure pulpal blood flow through the intact tooth surface, can provide a more accurate assessment of pulpal health in traumatized teeth, and can also be used to monitor the effects on the pulp of laser irradiation, maxillofacial surgery, and other treatment processes.

As research in this area continues, major advances can be expected. Such advances will be particularly important in the care of numbers of highly restored teeth in older patients over the next several decades.

3.2 Periodontal diseases

3.2.1 Periodontal diagnosis

Traditional approaches to periodontal diagnosis include assessment of gingival health, and measures of pocket depth, alveolar bone height, and
loss of periodontal attachment. In addition, the presence or absence of
dental plaque and supra- and subgingival calculus is recorded. Assessment
of gingival health continues to rely on visual evaluation of the tissues and
the extent to which gingival bleeding can be provoked by gentle probing.
The height of the alveolar bone is assessed from radiographs. However, a
complete assessment of the periodontal situation should include
quantification of the loss of attachment around the teeth (pocket depth and
gingival recession as measured from the cemento-enamel junction or some
other fixed point). It is important to note that pocket depth, bone height,
and periodontal attachment represent only the cumulative results of past
pathological events, and do not reflect the rate of progression of lesions
unless measurements of radiographic assessments are made at close time
intervals. Recently, subtraction radiography and nuclear medicine
technology, such as the utilization of radionuclide technetium 99m-tin
diphosphate, have proved their value in identifying “active” periodontal
lesions. Many diagnostic tests aimed at detecting early events in the disease
process, such as bacterial cultures, DNA probes, immunofluorescent
assays, specific antibody determinations, and the measurement of
hydrolytic enzymes, breakdown products, and cytokines, are currently
being studied. Markers of host defence mechanisms, such as chemotactic
responses and phagocytic capability of polymorphonuclear leukocytes,
have also been investigated.

Use of sophisticated tests like these in addition to conventional diagnostic
tools may be of assistance in diagnosing periodontal disease when higher
sensitivity, specificity, and accuracy can be demonstrated.

3.2.2 Demands for treatment

Epidemiological studies from many countries around the world show that
severe periodontal destruction is less prevalent than it was thought to be
10-15 years ago. Other reports, from Europe and the United States of
America, for example, indicate that periodontal health is actually
improving: not only is gingivitis in children decreasing, but better
periodontal health among adults has also been recorded. Improvements in
oral hygiene are believed to be the primary factor in this change.

Because of declining caries rates and the increasing interest in oral health,
more people will retain their teeth into old age. Greater life expectancy also
implies that older individuals will make up a larger part of the total
population, and that there will be greater demand for a functional and
socially acceptable natural dentition for life. As a result, people in the older
age cohorts in industrialized countries will seek more periodontal care. At
the same time, periodontal care will also be needed by the many elderly
people who are medically compromised, have physical and mental
handicaps, live in nursing homes, or take medications with potentially
harmful side-effects.
3.2.3 **Treatment of gingivitis**

Treatment of gingival inflammation (gingivitis) and maintenance of gingival health depend on adequate plaque control through self-care. Instruction in good oral hygiene and constant practice early in life may lead to good habits in adults which will help to prevent the formation of calculus. Regular examinations and frequent removal of calculus are also beneficial.

3.2.4 **Adult periodontitis**

Moderate or advanced periodontitis can be successfully treated by elimination of bacterial infection (removal of bacterial plaque and calculus) and establishment of effective plaque control. It has been conclusively demonstrated that the large majority of periodontal problems can be treated using non-surgical, conservative approaches. It should also be noted that high levels of calculus with relatively little concomitant pocketing or loss of periodontal attachment have been observed among large populations in developing countries.

3.2.5 **Tissue regeneration**

A better understanding of the biology of connective tissue and of the regenerative potential of periodontal tissues has given rise to new approaches to restoring periodontal attachment. Guided tissue regeneration procedures have been shown to lead to the formation of new fibrous connective tissue, anchored in new root cementum, and of new alveolar bone. This approach appears to have great potential value for individual teeth in individual patients but cannot at present be viewed as a significant measure to be applied at the public health level.

3.2.6 **Juvenile periodontitis**

Early-onset periodontitis occurs in approximately 0.5% of the adolescent population of the USA. *Actinobacillus actinomycetemcomitans* is present in most of the lesions in these individuals and is thought to be pathognomonic of the disease. Recent studies, however, failed to find *A. actinomycetemcomitans* in similar lesions in a group of Chinese adolescents ([19]). Many individuals with rapidly progressing disease exhibit deficient chemotactic and phagocytic activities in the polymorphonuclear leukocytes. The condition appears to be familial and is characterized clinically by inflammation and rapid progression of the periodontal lesion. Presence of *A. actinomycetemcomitans* may be an early marker of the disease.

Although research during the past few decades has led to greater understanding of early-onset periodontal disease, much remains to be learned about the condition and about the variant of this aggressive form of disease which sometimes occurs in the adult population.
3.2.7 *Necrotizing ulcerative gingivitis*

This condition, and its most severe form, noma, appear to be associated with malnutrition in children in some parts of the world, although confirmatory data are lacking. Necrotizing ulcerative gingivitis and stomatitis are also sometimes associated with HIV infection (see section 3.6).

3.3 **Malocclusion**

Orthodontic treatment is aimed primarily at malocclusion that lies within the normal range of variation. Most cases of malocclusion are not pathological in origin, and so the potential for prevention or biomedical treatment is very limited. The main emphasis in orthodontic research is therefore laid on assessment of the effects of various forms of treatment and on improvements in appliance design. Examples of advances in these areas include:

- improved design of brackets, archwires, and headgear;
- improved aesthetics through bonding agents and ceramic brackets;
- standardized indices and reliable measures of malocclusion, treatment needs, and outcomes;
- increased understanding of the mechanics and long-term effects of treatment; and,
- computerized programmes to aid in diagnosis and analysis of treatment.

3.4 **Missing teeth**

Tooth loss has decreased significantly over recent years. Edentulousness is being reduced dramatically in those parts of the world where levels were once very high. However, edentulousness and replacement of teeth will remain issues of concern for several decades, partly because of aging populations, but also because large cohorts of people are still suffering the life-long sequelae of dental caries and restorative treatment.

Most people want to retain their teeth. When that is impossible, they seek tooth replacement to maintain an aesthetically and socially acceptable appearance. The question of whether all spaces need to be filled is still valid. The aim of at least 20 functioning teeth, not requiring prosthesis, mentioned in the WHO/International Dental Federation Goals for the Year 2000 and in Japan as the “8020” programme (at the age of 80, at least 20 remaining teeth) is not an absolute goal, but rather a milestone on the road to retention of all natural teeth in future generations (20, 21).

When it is not functionally or aesthetically necessary, and if occlusal disharmonies are not causing myofacial pain or problems of the temporomandibular joint, teeth should not be replaced. If replacement becomes necessary, however, it should be carried out with minimal tissue invasion. Prostheses that endanger the remaining dentition and/or supporting tissues are to be discouraged. The concept of a shortened
dental arch (bicuspids to bicuspids) seems to be a realistic approach when caries levels are high and resources are limited. Loss of anterior teeth complicates the problem: the development of bonded replacements represents a major advance in dealing with single losses, but multiple replacements are more difficult.

3.4.1 **Dental implants**

Dental implants offer a further option for replacing missing teeth without unnecessarily damaging adjacent tissues or compromising function. For more than 10 years, successful implants have combined appropriate surgery with a tissue-compatible material and appropriate prosthetic concepts. The principle of osseointegration of dental implants using highly biocompatible materials has provided the oral health profession with opportunities far in excess of the original concept of tissue restitution. During the past decade, implementation of this principle in the treatment of total and partial edentulousness has contributed to a rapid increase in replacing removable dental prostheses with fixed restorations.

Osseointegrated implant procedures depend heavily on technique and on the competence of the practitioner. Appropriate training and equipment are thus mandatory for good results. The use of fresh socket wounds as implant sites is now being studied as a means of bringing this technology within the scope of general practice. This method is expected to be less technique-sensitive than the current procedure, but to what extent remains to be demonstrated.

3.5 **Oro-facial lesions**

Research over the past 30 years has provided a wealth of information about the various oro-facial diseases. It is now known that numerous systemic diseases have oral manifestations, and that the complicated interaction between oral and systemic disease will have implications for the teaching and practice of medicine and dentistry. The concept of the whole patient and his or her behaviour and social environment as important determinants of the approach to oral health care demands that health workers in all fields become partners in the provision of oral health care.

Although there is still much to learn about etiological and precipitating factors in many oral diseases, great advances have been made and have allowed clarification of remaining difficult areas. International oral medicine meetings, and in particular the recently introduced World Workshops in Oral Medicine (22), have served to unify international opinion and helped to establish common grounds.

Oro-facial lesions include primarily viral, bacterial and fungal infections, ulcerations, precancerous lesions, oral cancers, and oral manifestations of systemic diseases. Prevention is still impossible in many cases, and treatment remains largely symptomatic rather than curative. However,
comprehensive evaluation of the patient, including assessment of lifestyle and risk profile, is essential in all treatment of oro-facial lesions. This evaluation includes a search for systemic disease and disease treatments as possible causative factors, and assessment of any other predisposing factors. The oral health worker of tomorrow will be in the forefront of the search for answers regarding the etiology, prevalence, prevention, and curative management of these lesions.

3.5.1 **Scope of the problem**

It is important to recognize that oro-facial diseases of other than dental origin are common. Aphthous ulceration affects 20% and more of some populations, xerostomia affects over 10% of adults, and herpes labialis (herpetic vesicular dermatitis) at least 15%. In addition, oral manifestations of systemic diseases are more common than was previously thought. Oral expressions of HIV infection and other diseases that suppress the immune system are the most obvious examples, but many other diseases affect the oro-facial region: most patients with primary biliary cirrhosis, and many with rheumatoid arthritis, for example, have oral problems related to secondary Sjögren syndrome.

3.5.2 **Infections of the oral mucosa**

The oral mucosa can be affected by any infective agent, but fungal, viral, and bacterial infections are the predominant sources of problems. Fortunately, laboratory techniques for the detection of these diseases are widely available. Major therapeutic advances in antiviral chemotherapy have been made, notably with the advent of aciclovir for the treatment of herpetic infections. In both systemic and topical therapy, aciclovir has been shown to be effective in reducing the duration of initial disease, but not the recurrence rate of, for example, herpes labialis.

For the diagnosis of fungal infections, a variety of new laboratory methods is available to supplement the traditional techniques of direct microscopy, biopsy, staining of smears, and culture. There is considerable interest in the role of saliva in the host defence against such infections, which has focused on the composition of saliva as well as on the quantitative decrease in saliva production. A major advance in the treatment of fungal infections has been the development of the triazole group of drugs, which are remarkably effective against oral candidiasis.

Bacterial infections of the oral mucosa are commonly seen in the form of pericoronitis in otherwise apparently healthy patients. The etiology is still uncertain, but the condition is thought to be polymicrobial. Intraoral manifestations of bacterial infection are increasingly encountered in immunocompromised patients and in those with sexually transmitted diseases. Research continues towards the development of newer and safer drugs for the treatment of these disorders, and prevention is a continuing long-term objective.
3.5.3 *Aphthous stomatitis*

Although the precipitating factors of aphthous stomatitis are not well understood, this common oral condition has been associated with stress and with some systemic diseases such as malabsorption syndrome. Nutritional deficiencies have also been linked to the disease. Various symptomatic treatment options have been proposed for patients with no detectable nutritional disorder, but very few have been the subject of properly controlled double-blind, crossover studies, and there is a known large placebo effect. Research is essential to address this gap in knowledge, and should include a search for other precipitating factors.

3.5.4 *Lichen planus*

Lichen planus is a common oral mucosal disease of unknown etiology, which often occurs without simultaneous skin lesions. In the ulcerated form, the disease often presents significant therapeutic problems. Occasionally, patients may present with lesions called lichenoid reactions, which are sometimes related to drugs and/or graft-versus-host reactions.

3.5.5 *Oral cancer and precancer*

Worldwide, oral squamous cell carcinoma is one of the more common cancers, although epidemiological and cancer surveillance studies have shown that its prevalence varies from country to country. Recent studies have pointed to an etiological role for genetic factors and malnutrition in oral cancer and precancer, but more information is needed regarding both these factors, as well as the effects of high-risk behavioural elements. The prevalence of these conditions and the high associated mortality demand early detection and better management.

Longitudinal studies have also shown that some oral white (and red) lesions show variable transformation rates to cancer; further research, similar to that proposed for oral cancer, is essential. There is an obvious need to improve methods such as flow cytometry, which is used for the identification of those lesions most likely to progress to oral carcinoma. Detailed study of host factors and prognostic indicators is also needed. At present, histopathological investigation of suspect lesions remains the method of choice for evaluating epithelial changes. Nevertheless, potential markers of transformation, such as blood antigens, cell surface carbohydrate fractions, DNA cytology, and oncogene expression, may in the future have an important part to play in early diagnosis and management. In terms of patients’ behaviour, smoking and alcohol abuse are still the major areas of concern in the progression of potentially malignant oral lesions.

Treatment of oral carcinoma remains largely surgical and radiotherapeutic, but the 5-year survival rate is unchanged. Patients’ quality of life has undoubtedly been enhanced by improved diagnostic and surgical techniques and rehabilitation, but only the very earliest
detection of disease can improve survival, as patients' behaviour is unlikely to change radically in the short term.

A wide range of other tumours involve the mouth and perioral tissues, notably salivary gland tumours and malignancies in immunocompromised hosts, including Kaposi sarcoma and non-Hodgkin lymphoma in those with HIV infection.

In addition, many other malignancies that are not located in the oro-facial region may cause oral problems, either as a direct result of the diseases themselves or as a consequence of cancer treatment. For example, the mouth is a prime source of septicaemia in patients with leukaemia, and oral lesions are particularly common in patients who are receiving cancer chemotherapy, who have had radiotherapy to the head and neck region, or who have had bone marrow and other transplants.

3.5.6 Oral diseases with an allergic basis

There is now some evidence that a number of oral conditions can be caused by allergies, and this has led to major advances in the understanding of host immunological response. Further research is required to clarify the mechanisms of immune injury to the oral mucosa. Conditions suspected of having an allergic basis include oro-facial granulomatosis and some drug-reaction lesions. In oro-facial granulomatosis there is a high concordance between avoidance of a foodstuff allergen which has been identified through patch-testing and the resolution of the disease. Details of the immune-mediated damage to the oral tissues remain to be elucidated.

Some oral mucosal lesions may be caused by or related to dental restoration. The pathogenesis of these lesions is not known, but may be attributable to type IV contact sensitivity to the restorative material. Research is continuing in this area.

A unified approach to the investigation and management of patients with a suspected allergic reaction of the oral mucosa is essential. Symptomatic immunomodulatory treatment options are useful, and slow-release drug delivery systems are being actively researched in this context.

3.6 Oral manifestations of HIV infections and AIDS

In most countries of Africa and the Caribbean region, and in Brazil, India (notably Bombay), and Thailand, the HIV epidemic is spreading with alarming speed. The WHO prediction for the year 2000 is now 10 million AIDS cases and 40 million HIV-seropositive individuals. In many cases, oral lesions are the first signs of HIV infection, and members of the oral health profession should therefore be well trained in recognizing these lesions. A classification of the oral conditions that have been reported to occur in HIV-infected patients has been produced by WHO and the
European Economic Community (see Annex). Those most strongly associated with HIV infection are the following:

- candidiasis
- erythematous
- hyperplastic
- pseudomembranous
  \((Note: \) Angular cheilitis is often associated with \textit{Candida albicans})
- hairy leukoplakia
- HIV-gingivitis
- HIV-necrotizing gingivitis
- HIV-periodontitis
- Kaposi sarcoma
- non-Hodgkin lymphoma

In patients with AIDS, treatment of oral candidiasis should follow general recommended guidelines; however, alleviation of the condition may take a comparatively long time to achieve, and use of the triazole drug fluconazole may be required. Necrotizing gingivitis and stomatitis are also frequently encountered in HIV-positive patients. Good oral hygiene is essential, supplemented with antibiotic treatment if necessary; the drug of choice is often metronidazole. For Kaposi sarcoma, various treatments are used, including radiotherapy, surgery, and intralesional cytotoxic drugs such as vinblastine. Like candidiasis, hairy leukoplakia is a strong predictor of AIDS; it is not a precancerous lesion, however, and no treatment is indicated.

Obviously, oral health personnel have an important role to play in the recognition of HIV infection, and have the further responsibility of ministering to the oral health needs of HIV-infected patients. They should be prepared to treat the commonest of the HIV-related oral lesions, especially oral candidiasis (to relieve discomfort and prevent spread), gingivitis, and periodontitis. Further research is needed to clarify the nature of these HIV-related periodontal lesions. Continuing education should emphasize their diagnosis and treatment, and the use of universal precautions to control infection for all patients and health workers.

Lesions of the oral mucosa related to secondary immunodeficiency are similar to the oral manifestations of HIV infection. These lesions are often encountered following organ transplantation, radiation, or chemotherapy – all procedures that are being performed increasingly throughout the world.

3.7 \textbf{Saliva and related structures}

Major advances have been made in research on exocrine glands, including salivary glands. Lymphocytic infiltrates of the salivary glands have been identified in a number of diseases, including Sjögren syndrome, rheumatoid arthritis, and HIV infection and AIDS. Moreover, the
autoantibodies identified in primary Sjögren syndrome and the salivary
gland IgM antibodies associated with primary biliary cirrhosis are similar,
although the clinical significance of these findings remains unclear.

Expanding research on saliva makes future analysis of flow rates and the
quantity and quality of salivary components important. Like blood and
urine analysis, analysis of saliva may soon serve as a routine source of
baseline information as well as of specific information related to individual
disorders. If a patient complains of a dry mouth, for instance, a diagnosis
should be established, the etiology clarified, and, if possible, the cause
reduced or eliminated. Many drugs are known to decrease salivary
function. If these are prescribed, patients should be evaluated for salivary
function by the prescribing clinician. No “saliva secretion depletion index”
has yet been established for individual drugs, but methods are being
developed which raise hopes of such a measure becoming available.
Transmitter substances that stimulate salivary secretion have recently been
identified, and this knowledge may enable the further development of
effective salivary stimulants. Potential side-effects must be minimized, and
new drugs, with actions targeted specifically to salivary glands, are needed.

It is important to realize that decreased salivary function may reflect
disease in other organ systems (e.g. Sjögren syndrome, diabetes mellitus,
HIV/AIDS). Xerostomic patients should also be put on a careful
prevention programme for caries, periodontal diseases, and candidal
infection. Further, the patients should be monitored for functional
deficiencies of the salivary glands, for pain, and for problems in taste
perception, eating, swallowing, and speech.

Many topical saliva-stimulating agents and saliva substitutes are available,
and new ones are being introduced. Although none possesses all the
desirable properties of natural saliva, the clinician should carefully select
the most appropriate remedy for each xerostomic patient.

Analysis of salivary immunoglobulins is being used in population studies
to determine the prevalence of HIV infection, and a similar approach
could be used to monitor a wide variety of other infectious diseases that
result in a host immunoglobulin response in the saliva.

3.8 Facial pain

It is generally fair to say that, until 10 years ago, the treatment of oro-facial
pain disorders was unsatisfactory, largely because of inadequate diagnosis
and definition of the various disorders and the limitations of the available
drug therapy. Major advances have now been made in conditions such as
burning mouth syndrome, giant cell arteritis, temporomandibular joint
dysfunction syndrome, and neuralgia, and for the majority of patients
treatment is much improved. However, there is still a need for more
knowledge of the main precipitating factors, such as psychiatric status, for
these diseases in susceptible individuals.
3.9 Advances in oral surgical techniques

Technological advances in other areas of surgery have improved diagnosis, treatment planning, treatment, and patient management in oral and maxillofacial surgery. In many parts of the world the trend is now to promote general medical and surgical expertise as part of the training of maxillofacial surgeons.

Some of the advances in diagnosis derive from developments in computerized tomography, magnetic resonance imaging, and thermography plotting. Deformities can be measured accurately, outcomes predicted, and morbidity reduced by using diagnostic radiology in conjunction with specially designed computer software. Microvascular surgery, a technique developed in plastic surgery, is also used for better repair of tissue in cases of trauma, surgery for cancer, or congenital soft and hard tissue defects.

The use of titanium miniplates and compression plating systems represents a major advance in bone fixation. Because the need for intermaxillary fixation is often eliminated with these methods, healing is usually safer, faster, and more comfortable for the patient.

Advances in orthognathic surgery have resulted from better liaison with orthodontists in pre- and postoperative management, and the availability of drugs that reduce both pain and swelling following surgery.

Arthrography, arthroscopy, and computerized tomography have allowed more accurate diagnosis of anomalies of the temporomandibular joint. Arthroscopy is also used for disc surgery. The use of non-steroidal anti-inflammatory drugs has reduced the need for invasive surgery of the joint; however, when joint replacement is necessary, biocompatible materials are now increasingly used, rather than autogenous bone grafts. Much research continues in this area.

Surgical instruments, associated equipment, and combinations of drugs have advanced considerably to provide better operator access, to control heat during the cutting of bone, and to reduce post-surgical trauma. A wide range of new broad-spectrum antibiotics has allowed more effective control of infection, and advances in the manufacture of ciclosporins have also reduced many of the allergic reactions previously encountered. New drugs are in use that enhance oxygenation and phagocytosis of necrotic and heavily infected tissue, thereby promoting rapid healing of traumatized soft tissue and bone.

4. Informatics

In oral health care, as in all areas of the medical profession, increasing computerization has been a major element of technological advance. Before considering specific computer applications, however, it is useful to reflect upon the massive and fundamental changes that will follow the
growing use of informatics in oral health. The trend to computerization is such in industrialized countries that, by the year 2010, most oral health care practices will have adopted the technology. These changes will affect the structure of care services, the place of oral health care within the health sector, the policies of public health dentistry, the oral health provider, the teacher, and the patient. There is, however, growing concern – expressed mainly by health administrators – that quality of care should be maintained and the costs of these changes kept within acceptable limits.

Three major developments are addressed in this section: electronic management of oral care, data transmission, and computer-assisted instruction. As the focus of computerization in the management of oral health shifts from financial to clinical, from office management and accounting systems to clinical data management, the issues to be confronted will include quality of care, cost-effectiveness, quality assurance, professional education, patient education, and self-care.

As regards data transmission, the principal areas of interest are integrated systems, standardized protocols, universally readable information, user interfaces that permit more “natural” means of communication (such as touching an image with a pen or a finger, or talking in usual language to the computer), and self-training based on interactive multimedia programmes such as video discs and CD-ROMs (compact discs, read-only memory).

4.1 Clinical records

It is crucial that the oral health profession takes an active part in the development of standards for the design of electronic clinical records, to ensure that they contain enough information to allow the assessment of quality of care and that they comply with the practical requirements of the care provider and with the needs for information in a public health perspective.

While there is always likely to be some conflict between the desire for innovation and the need for standardization, experience at all levels of informatics has shown that some degree of standardization is important for practical implementations. Standardization is clearly essential if the full benefits of computerization of clinical records in oral health are to be realized. Indeed, standardization is occurring de facto through health insurance or third-party payment systems, but requires a broader professional input to ensure that adequate attention is paid to issues beyond the interests of insurers.

One of the characteristics of high-quality care is that the services provided are carefully selected to accord with the unique needs and circumstances of the individual patient. It has long been considered good practice for health care professionals to record details of a patient’s symptoms, signs, diagnosis, treatment, and sequelae (if any). This systematic recording of relevant information provides the data needed to assist the clinician in making an accurate diagnosis, developing a rational treatment plan, and
providing continuity of care. For optimal care, this type of information must be accumulated over the long term and carefully evaluated, both for the individual patient and for the patient population as a whole.

Historically, clinical records have a value that extends beyond the needs of the individual patient. Their accurate maintenance has enabled health practitioners to publish case-studies – of single cases and of large clinical trials involving sophisticated investigative and analytical techniques – and thus share a wealth of knowledge and experience with colleagues. In future, if appropriate clinical data can be recorded systematically and stored in a form that is readily retrievable and that allows aggregation with similar data from other sources, invaluable information on community patterns of oral diseases and conditions, risk profiles, treatment choices, and outcomes will become available.

At present, one of the principal obstacles to full realization of this potential is the lack of standardization, both of the contents of clinical records and of the nomenclature. Consistency is of paramount importance. Oral health has some advantages over other areas of health care in this respect, in that there are well developed methods of quantifying discrete data; much of the detail is already highly amenable to computerized recording.

Standardized recording systems would allow the aggregation and comparison of data from oral health practices throughout a particular country or region. This, in turn, would permit the broad assessment of disease patterns and treatment options, as well as allowing analysis of the effects of different schemes for delivering and financing oral health care. Standardization of clinical records on a national or international basis is a relatively low-cost option that would yield significant benefits.

The principles of noting information as outlined above apply equally to all types of oral health care setting, from those that provide only basic emergency care to those with facilities for the most sophisticated preventive and restorative services. However, standardization of clinical recording does not necessarily imply that all practitioners record identical details for all patients. The needs of the individual patient, the type of care available, and the philosophy of the particular oral health care practice dictate that clinical records must vary accordingly, and any system of standardization must be capable of accommodating this variation. Standardization should apply at the level of the general content of clinical records, with variable detail superimposed according to circumstances. Aggregation of data will demand careful methodology to allow comparability between patients and across practices, but the practitioner will retain flexibility in the amount of detail recorded.

More creative information management strategies will become possible with the greater availability and relative cheapness of powerful computing systems. The underlying principles of standardized recording, however, are not exclusive to computer systems, and should be applied even where
computerization has yet to be implemented. Every effort is needed to develop consensus on the approach to standardizing clinical records and the means of accommodating additional detail when necessary.

4.2 Data transmission

Another aspect of the rapid and somewhat random process of computerization in health sectors is that of “distribution” of computing. It is not uncommon for the various health departments to tackle their computing needs in isolation, with the result, for example, that the radiology department will have a radiology information system, the laboratory a laboratory information system, and the pharmacy a pharmacy information system. Direct exchange of information is recognized as essential to improved management of health care, but its implementation can be difficult and costly. Nevertheless, the move towards integration has already taken place to a greater or lesser extent in various countries.

In oral health, as in other health sectors, the future lies in local, national, and international transmission of data: as the technology develops, transmission of images as well as of textual matter will become routine. Although the essential networking infrastructure is likely to develop unevenly in different countries and in different sectors, the whole process should not take more than 10-20 years in the industrialized world.

4.3 Computer-assisted instruction

A third area in which important changes are imminent is that of computer-assisted instruction. Progress in computer and video technology has brought with it the opportunity for revolutionary developments in educational methodology. The video disc, for example, can store text, images, sound, and graphics; linked to a computer, it can provide a self-teaching package within an interactive programme. The CD-ROM (compact disc, read-only memory) is less expensive than the video disc, more readily available, and more convenient. It has a storage capacity of 600 megabytes, is about the same size as the more familiar audio disc, and stores both sound and digitized images. It can thus provide a complete multimedia training system.

The significance of “multimedia” technology and its potential for teaching and diagnostic purposes have yet to be fully realized in the field of health sciences. However, there is a growing body of opinion that the multimedia approach will become essential to health sciences education at both undergraduate and postgraduate level. Its eventual acceptance will necessitate a radical change in the role of both teacher and student, and extensive modification of curricula.

Since 1960, the advent of interactive computer systems and of new learning theories has brought about a change in emphasis in teaching techniques. Conventional lectures and practical classes are being increasingly supplemented by interactive learning methods for small
groups and by self-instruction. Education thus becomes less a matter of repetition, imitation, and conditioning, and more a cognitive process.

It is important to make the distinction between computer-assisted evaluation and computer-assisted instruction. The sole purpose of evaluation is to test the student's knowledge by asking a series of questions; the answers are corrected and a mark is awarded. The questions and the tests of knowledge used in computer-assisted instruction, on the other hand, are designed to guide the educational process on the basis of the student's responses, providing appropriate input and support. However, since learning must at some stage be evaluated, the two processes are complementary.

Computer-assisted instruction, additionally, allows the student to work at his or her own pace. It avoids the linear approach of the textbook by providing a variety of routes to the acquisition of particular knowledge and access to the highest levels of expertise.

Developing countries often lack an adequate number of teachers, and for many students — access to the educational infrastructure is difficult. The needs for both initial training and retraining are growing rapidly in the field of health care. Meeting those needs is constrained not only by the limited numbers of qualified clinicians and allied health workers, but also by the fact that these personnel are already fully occupied with their routine work, leaving little, if any, time for teaching. In these circumstances, there is a strong argument for the development of decentralized education systems in which self-learning plays a large part. For maximum effectiveness, such systems should be adapted to local needs and, where possible, integrated with conventional teaching methods to avoid conflict with the content of existing courses.

Computer-assisted instruction thus has a valuable role to play in this type of setting. It permits personalized learning, tailored to the knowledge that the individual already has and to the pace at which he or she is capable of progressing. An added advantage is the robustness of the media, especially the CD-ROMs. Nevertheless, it is important to note the drawbacks. Microcomputer equipment is much less freely available in developing countries than in other parts of the world, and its cost may be regarded as prohibitive where financial resources are limited. Equipment specifications change rapidly, giving rise to obsolescence, and the facilities for basic maintenance may be scarce.

4.4 Other developments

Information technology holds still further potential for application to oral health care. Direct registration and handling of clinical record data may become possible with voice input/output systems. The institution of decision-support systems could prove invaluable in the diagnosis, treatment, and preventive care of many oral conditions, particularly complex perio-prosthodontic problems, diseases of the oral mucosa, and
functional disorders. Major improvements can also be expected from the increasing use of interactive, multimedia, technology-based educational programmes. Considerable progress should also be made in oral radiography and screening, and in the computer-aided design and manufacture (CAD/CAM) of fillings, crowns, and bridges.

The relatively new development of teleradiology is proving especially valuable to small rural practices that need to consult with specialists in more sophisticated treatment centres. Radiographs and other diagnostic information are sent over normal telephone lines by a process similar to closed-circuit television. Since various communication options and image formats are available, standardization will become important in this area too.

5. **Implementation and consequences**

One of the most fundamental advances in oral health care has been the increasing emphasis on its scientific basis. Research has done much to clarify the biological mechanisms involved in oral health and the prevention of disease, and to increase understanding of the nature of the two main oral diseases, caries and periodontal disease. Undoubtedly, this has revolutionized all aspects of oral health care. As a result, a primarily technical profession with a relatively narrow focus has adopted a more appropriate role as a broadly and scientifically based biomedical discipline; “dentistry” has become “oral health care”.

The preceding sections of this report have described many advances in oral health care technology and materials, and clinical methods. Some of the most important of these have concerned the mechanisms of action of (and the increasing variety of vehicles for) fluoride, the use of pit-and-fissure sealants, and the availability of caloric and non-caloric sugar substitutes to prevent dental caries. Diagnostic tests are now available for measuring levels of specific pathogens in the oral bacterial flora, and antimicrobials have been developed or adapted for reducing the levels of these organisms. Implants are being increasingly used in fixed replacements for lost teeth, by methods that do not involve invasion of other natural teeth.

These and other factors have contributed to radical improvements in oral health in many parts of the world. Caries has declined dramatically over the past decade, at least in most industrialized countries. Periodontal destruction has been shown to be less prevalent than was thought 15 to 20 years ago, and it has been demonstrated that periodontal health is actually improving in much of Europe and the United States. Tooth loss and edentulism are declining in countries where rates were once high. Thus, the goal of virtually eliminating the two main oral diseases now appears to be not only reasonable but also attainable for a large majority in most populations.
Corresponding changes are taking place in patterns of care delivery, with the emphasis shifting from curative to more preventive patient care. It is now possible to pursue realistically the ideal of maintaining oral health rather than treating disease. If treatment becomes necessary, many approaches are now available that allow the conservation of tissue. Initial carious lesions can be treated with remineralizing agents and sealant procedures, and larger lesions can be repaired with minimal tooth preparation. It has also been demonstrated that the large majority of periodontal problems can be treated in general practice using non-surgical, conservative approaches. Eventually, it should be possible to extend this less invasive and more conservative approach to most, if not all, oral health care.

It is important to note that these advances may ultimately be applied at all levels of oral health care. While it is obvious that the new materials and methods discussed here will not all be applicable in all situations, the basic principles should be relevant and beneficial in any setting. One of the greatest advances, especially for oral health care providers in settings where resources are limited and high-technology equipment is scarce, is the preventive, less invasive approach to oral health care, including excavation with hand instruments and restoration with adhesive restoratives such as glass ionomers. This concept should be considered “state of the art” in any setting and should encourage the attitude that complex restorative dentistry is not necessarily “ideal” care. Practical measures for disease prevention coupled with minimally invasive techniques for restoration constitute the best and most advanced care that can be provided, and are also highly cost-effective.

In considering the potential impact of these new concepts on the infrastructure for oral health care delivery, including the categories and numbers of personnel required to sustain these advances, the Committee felt compelled to refer extensively to the report of the Expert Committee on Educational Imperatives for Oral Health Personnel (14). That report warned that “In the immediate future all countries will be faced with the problem of reorganization and transition of the oral health workforce, and each must take the actions it sees as appropriate. Longer-term strategies must be adopted for the implementation of more fundamental changes.” The report further emphasized that it will be “essential to recognize that:

- A clear new policy is needed as soon as possible, which will include firm choices between the various alternative approaches.
- This policy and operational plan must cover the education and training of all types of oral health personnel and retraining of those already in the workforce by the time implementation of the plan commences.
- The prime objective ... is to provide appropriate personnel for care of a country's oral health, and that this cannot be achieved simply by adjusting the numbers and sizes of existing dental schools or without thorough revision of the educational process and the content of courses.”
5.1 **Personnel**

A new type of dentist is required, who will be a broadly trained "oral physician", responsible for the continuing care of the oro-facial region. These oral physicians of the future will be the leaders of oral health teams concerned with health education, disease prevention and treatment, and maintenance of patients' health, and will be supported in this work by auxiliaries such as nurses and hygienists with extended duties. They will require skills in diagnosis and treatment planning as well as dental surgical techniques. The broader range of responsibilities will necessitate an approach based on continuity of care for patients' oral, dental, and general health. Oral and dental diseases will be prevented, diagnosed, and treated by the oral health team with full knowledge of a patient's medical history, lifestyle, family, socioeconomic, and other environmental circumstances, as well as familiarity with the clinical manifestations of dental, oral, and systemic disease.

The roles of different members of this team will change progressively. Oral care therapists and personnel such as oral hygienists will have a larger range of tasks at the moderate-technology level. In many countries, these personnel will be the main providers of routine restorative and related care, as well as of guidance and supervision for primary health care workers. Depending on the evolution of disease patterns in different countries, oral health care tasks in the community (mainly promotion of, and assistance in, self-care and family preventive care, provision of regular screening care for common oral problems, and appropriate referral) will be performed by a variety of health care workers, including teachers specially trained for such tasks.

5.2 **Work environment and support**

The oral health team will require the support of computer systems, as well as of medical and dental laboratory services. They will work with other primary medical services and with specialist services that might include oral and maxillofacial surgery, orthodontics, and advanced restorative care, according to the prevalence of different diseases and the availability of resources in the country concerned.

Standard sets of equipment and supplies should be defined and recommended for oral health care settings at different referral levels. Similarly, design specifications for efficient and effective oral health care facilities in a wide range of clinical settings can be adopted for the provision of high-quality care at affordable cost. The underlying principles of this approach should form an integral part of oral health care training programmes.

5.3 **Education and training**

Referring again to the report of the Expert Committee on Educational Imperatives for Oral Health Personnel (14), the Committee strongly endorsed the statement that:
It is apparent that [the] educational structure must have the characteristics of flexibility and ease of adaptation to changing needs. Any proposed structure should be able to fulfil the educational requirements of all members of the oral health care team. Thus, it should not only cater for personnel who will carry out tasks of differing complexity, but should also meet their career-long requirements for continuing education.

Oral health care will become increasingly closely related to general health care. Accordingly, the educational setting for oral health personnel should be one that enables close links to be established with teaching and research staff in the biomedical, social and clinical sciences. Isolation of oral health education from other major health care disciplines would be disastrous.

6. Recommendations

6.1 Self-care and low-intervention oral health care

A minimally invasive, low-intervention approach to oral health care is recommended for most people in most parts of the world. Emphasis on self-care and a healthy lifestyle should be an integral part of this approach. With the decline in dental caries, the recognition of lower levels of destructive periodontitis in economically developed countries, and the development of new materials, a less invasive approach to oral health care is considered the optimal concept, applicable in almost all circumstances around the world. In adopting this approach, every effort should be made to introduce and use the wide range of advances described in this report.

6.2 Technology transfer

The expert knowledge and technical excellence that are available must be transferred in forms that are technologically and economically appropriate to the setting. For example:

- Preventive and non-invasive approaches to caries and periodontitis should be promoted.
- Easily applied approaches to risk assessment and modification of lifestyle should be developed.
- Fluoride delivery through water, salt, or milk is highly effective and to be encouraged. However, toothbrushes and fluoride-containing toothpastes could also be highly effective in much of the world if they were more generally affordable.
- Simple and efficient instruments, materials, and equipment should be made available to developing countries: the excellent should be adapted to achieve the appropriate.
• Simpler and less technique-sensitive methods of tooth replacement, which are not damaging to the remaining dentition, should be encouraged, but will require highly sophisticated development.
• Affordable methods for collection and analysis of epidemiological data are needed for monitoring, planning, and evaluation.

6.3 **Informatics developments in the advancement of oral health**

1. Cost-effective computer-assisted instruction methods are needed to reduce the costs of educating oral health personnel.

Computer-aided instruction should be used to develop an “electronic curriculum” which will make the most up-to-date education available for the training of oral health personnel in all parts of the world. This approach has the advantage of being student-oriented and of enhancing the scope of teaching without requiring the continuous presence of expert teaching staff. These materials can be regularly updated much more cheaply than is the case for printed materials.

Computer-aided instructional packages can also be used for the retraining and continuing education of oral health personnel.

2. Development and implementation of standards for clinical records should be encouraged, so that the benefits of information management can serve the decision-making process and allow appropriate oral health care to be implemented. WHO should help to coordinate initiatives already under way in various countries to develop a consensus on standards for patient records to ensure that they comply with the ethical demand for quality of care, and with the need for information in a public health perspective.

3. An informatics infrastructure should be developed to include interactive and international networking, to provide for distribution of summaries of scientific advances. Where appropriate, this could start by concentrating on caries and periodontal diseases prevention, but would prepare for similar emphasis in other areas, such as mucosal lesions and oral cancer.

The development of informatics networking within WHO’s Collaborating Centres in oral health should be encouraged.

6.4 **Enhancement of scientific research**

Basic science and research should be promoted in a wide range of health-related areas, and special attention must be paid to encouraging practical adaptations of research findings through challenges to both academic institutions and industry.

Projects that demonstrate the workability and effectiveness of the preventive and more broadly based approach to oral health management should be initiated, particularly in developing countries.
6.5 Broadening the scope of oral health care

The education and re-education of personnel should evolve to encompass the full scope of oral health needs beyond the traditional areas of caries and periodontitis. The mix of oral health personnel should evolve to be in balance with the needs of the population and the available resources. The changes implicit in this evolution should be built around the concept of achieving better health through the health care model in which there is optimal integration of all health services.

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References


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**Selected further reading**


Annex

Classification of oral lesions associated with HIV infection¹

Group 1. Lesions strongly associated with HIV infection

Candidiasis
  erythematous
  hyperplastic
  pseudomembranous
Note: Angular cheilitis is often associated with *Candida albicans.*
Hairy leukoplakia
HIV-gingivitis
HIV-necrotizing gingivitis
HIV-periodontitis
Kaposi sarcoma
Non-Hodgkin lymphoma

Group 2. Lesions less commonly associated with HIV infection

Atypical ulceration
Salivary gland diseases
  dry mouth due to decreased salivary flow rate
  unilateral or bilateral swelling of major salivary glands
Thrombocytopenic purpura
Viral infections (other than Epstein-Barr virus²)
  cytomegalovirus³
  herpes simplex⁴
Human papilloma virus (wart-like lesions)
  condyloma acuminatum
  focal epithelial hyperplasia
  verruca vulgaris
varicella-zoster virus⁵
  varicella
  zoster

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¹ As agreed at a meeting of the EEC-clearinghouse on Oral Problems Related to HIV infection, held in Amsterdam, 30–31 August 1990.
² Human (gamma) herpesvirus 4.
³ Human (beta) herpesvirus 5.
⁴ Human (alpha) herpesvirus 1 and 2.
⁵ Human (alpha) herpesvirus 3.
Group 3. Lesions possibly associated with HIV infection

Bacterial infections (excluding gingivitis/periodontitis)
   Actinomyces israelii
   Enterobacter cloacae
   Escherichia coli
   Klebsiella pneumoniae
   Mycobacterium avium-intracellulare
   Mycobacterium tuberculosis
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<tr>
<th>No.</th>
<th>Date</th>
<th>Title</th>
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<tr>
<td>808</td>
<td>(1991)</td>
<td>WHO Expert Committee on Drug Dependence</td>
<td>Twenty-seventh report (17 pages)</td>
<td>6.--</td>
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<tr>
<td>811</td>
<td>(1991)</td>
<td>Control of Chagas disease</td>
<td>Report of a WHO Expert Committee (95 pages)</td>
<td>14.--</td>
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<td>813</td>
<td>(1991)</td>
<td>Safe use of pesticides</td>
<td>Fourteenth report of the WHO Expert Committee on Vector Biology and Control (27 pages)</td>
<td>6.--</td>
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<tr>
<td>814</td>
<td>(1991)</td>
<td>WHO Expert Committee on Biological Standardization</td>
<td>Forty-first report (79 pages)</td>
<td>11.--</td>
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<td>818</td>
<td>(1992)</td>
<td>Vector resistance to pesticides</td>
<td>Fifteenth report of the WHO Expert Committee on Vector Biology and Control (62 pages)</td>
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<td>819</td>
<td>(1992)</td>
<td>The hospital in rural and urban districts</td>
<td>Report of a WHO Study Group on the Functions of Hospitals at the First Referral Level (74 pages)</td>
<td>12.--</td>
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<td>820</td>
<td>(1992)</td>
<td>Recent advances in medically assisted conception</td>
<td>Report of a WHO Scientific Group (118 pages)</td>
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<td>821</td>
<td>(1992)</td>
<td>Lymphatic filariasis: the disease and its control</td>
<td>Fifth report of the WHO Expert Committee on Filariasis (71 pages)</td>
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<td>822</td>
<td>(1992)</td>
<td>WHO Expert Committee on Biological Standardization</td>
<td>Forty-second report (89 pages)</td>
<td>12.--</td>
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<td>823</td>
<td>(1992)</td>
<td>WHO Expert Committee on Specifications for Pharmaceutical Preparations</td>
<td>Thirty-second report (140 pages)</td>
<td>17.--</td>
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<td>824</td>
<td>(1992)</td>
<td>WHO Expert Committee on Rabies</td>
<td>Eighth report (90 pages)</td>
<td>12.--</td>
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* Prices in developing countries are 70% of those listed here.