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REVIEW ARTICLE

What is an appropriate caries diagnosis?

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Abstract

This aim of this paper is to spur a discussion of the direction of caries-lesion detection activities in clinical dental practice. It is argued that since the dental clinician's caries-related decision making is a script-matching enterprise in which clinical decisions are made on the basis of 'this-lesion-needs-this-kind-of-treatment' reasoning, the methods and strategies employed for caries lesion detection should accommodate this fact. This may be done by employing a clinical visual–tactile method for caries lesion detection that evaluates the two aspects that are crucial for appropriate caries management: lesion activity and surface integrity. The use of diagnostic methods that do not assess these features directly but involve assumptions about activity status and surface integrity should be avoided. This includes the use of bite-wing radiography for the detection of approximal caries lesions, as it may be shown that plain reliance on radiographs leads to considerable overtreatment. If clinical dentistry is to retain its status as a profession committed to doing good, changes in diagnostic practices along these lines are warranted.

Key Words: *Adverse effects, caries, clinical practice, diagnostic methods, screening*

Introduction

In the course of just a few years, several conferences have been held [1–3] and books have been written [4] that have addressed the issue of how best to go about diagnosing caries in various settings, which may include daily dental practice, clinical research, epidemiology or population oral health surveillance programmes. However, among the settings listed, the daily dental practice setting remains the most important since the reasons why we continue to carry out clinical and epidemiological caries research and continue to run population oral health surveillance programmes all originate in the fundamental fact that people, and in some populations all people, continue to experience new dental caries lesions over time. Dental practitioners may play a central role in helping patients to control their caries situation, as they may be able to observe caries lesions long before they are sufficiently advanced to produce the symptoms that would otherwise prompt the patient to seek treatment. Thereby, the key 'raison d'être' for the dental profession, which also includes those of us who are involved in clinical and epidemiologic research on dental caries, is our ability to help people control their caries situation. In most countries, the organization of the dental healthcare services is based on the idea that the general dental practitioner constitutes the key to the control and management of dental caries, and it is for this reason that any discussion of better caries diagnostic methods should take as their starting point what goes on in the meeting between the patient and their general dental practitioner.

Clarification of terms

As used here, the term 'patient' refers to any member of the public who is consulting a general dental practitioner. Patients may do so for one of two principal reasons. The patient has either gone to have their regular dental check-up, or they have gone because of a tangible problem for which they seek assistance from the dental practitioner. In the check-up situation the patient has no perception of any dental treatment being necessary but goes in the hope of being told that all is well, and possibly also to receive preventive care, which may include variable combinations of

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fluoride applications, scaling and polishing, fissure sealants and preventive advice [5,6]. The core activity carried out by the practitioner during the check-up visit is a dental examination of the oral mucosa, the periodontium and the teeth. Thereby, the check-up visit effectively becomes an oral screening procedure [6,7]. In the check-up situation, differential diagnostic considerations play little role except for possible mucosal lesions. When it comes to the periodontium and the teeth, the dental practitioners know exactly what they are looking for, and in the case of dental caries the objects sought for are caries lesions in need of treatment.

There is a growing recognition among researchers in the field of dental caries diagnosis that the same terms may have very different meanings in different quarters [8–10]. A higher degree of precision in the terminology used has therefore been advocated [11]. Even so, the terms used in the field of caries diagnosis continue to be an object of confusion, and despite several attempts to delineate their precise distinction [1,8,9,11,12] it is not evident how all of the terms 'caries measurement', 'caries scoring', 'caries detection', 'caries diagnosis', 'caries assessment' and 'caries monitoring' are helpful in bringing clarity to the field of caries diagnosis. In this review, the term 'caries detection' denotes the process of identifying caries lesions in need of treatment during a clinical examination in a general dental practice setting. The key reasons for not using the term 'caries diagnosis' are that proper caries diagnoses are rarely made in clinical dentistry [13,14] and differential diagnostic considerations are greatly downplayed and replaced by a pattern-recognition process [13,15].

Caries detection—caries script matching

Dental school taught us that any diligently exercised caries examination begins with a careful visual–tactile inspection, in which each single tooth surface in the dentition is evaluated in a standardized and sequential manner for deviations from its normal appearance with respect to colour, lustre, surface texture and surface integrity [16]. Thereby, a single caries examination involves the visual–tactile inspection of up to 148 tooth surfaces in the patient. As a normal working day in general dental practice typically involves the examination of dozens of patients, it is hardly surprising that this diagnostic process soon becomes rather more automated, and that the discrete differential diagnostic steps outlined above are no longer undertaken. Instead, the caries diagnostic process soon develops into a pattern-recognition process, which means that each tooth surface is scanned for its similarity to one of a finite set of clinical patterns or caries scripts retained in the clinician's mind.

A caries script is a highly summarized version of the clinician's cumulative experience with similar clinical presentations [13]. If, during inspection, a departure from 'normal' is detected, a rapid and unconscious review is undertaken of the dental clinician's inventory of caries scripts to establish if one of them matches the presentation. Importantly, once a matching caries script has been identified, the treatment decision is often given by virtue of the script. Thereby, diagnostic considerations are altogether skipped and replaced by scripts in the form of 'this-type-of-lesion-needs-this-kind-of-treatment' decisions [10,13,14], and dentists often 'diagnose' lesions for treatment using the intended treatment to identify and describe the observation in charts and patient records [13,17].

If the observations made during clinical inspection do not match one of the many caries scripts retained in the clinician's mind, the clinician is typically prompted to collect additional information using ancillary diagnostic devices. Unless the use of bite-wing radiographic information is already incorporated in the script-matching process, which may indeed occur [18,19], the ancillary information would most commonly be provided by the use of bite-wing radiographs, although other sense-enhancing methods might also be considered. The clinician scans the radiographic image and uses this additional information to improve the matching of the clinical and radiographic presentations to one of the caries scripts.

The key question is whether our caries-related treatment decisions inevitably result in the best decisions. Unfortunately, the answer to this rhetorical question is 'no'. This conclusion follows from the numerous observations that dentists vary considerably in their caries detection and treatment decisions [14,20–43] for the same teeth and the same patients. It is just a matter of simple logic to conclude that if two dentists disagree on the presence of a lesion on a surface, at least one of them is wrong. Similarly, if two dentists agree on the presence of a lesion but decide to intervene using different treatments, it logically follows that one of them has provided a less-desirable treatment [14,44,45]. It follows that the seemingly simple and straightforward process of detection of deviations from normal and the sorting of abnormal observations into distinct 'this-lesion-needs-this-kind-of-treatment' groups hides several problems that jeopardize the value of the activity.

As shown in Figure 1, the many sources of influence on the caries-related treatment decisions made in clinical dental practice broadly fall into two categories: the patient factors embrace the nature and strength of signals emanating from the patient presentation, whereas the dentist factors include the elements that form and shape the dentist's inventory of caries scripts. It is within the realms of dentistry to control the dentist factors, and for reasons that will be detailed later in this article it is high time that the

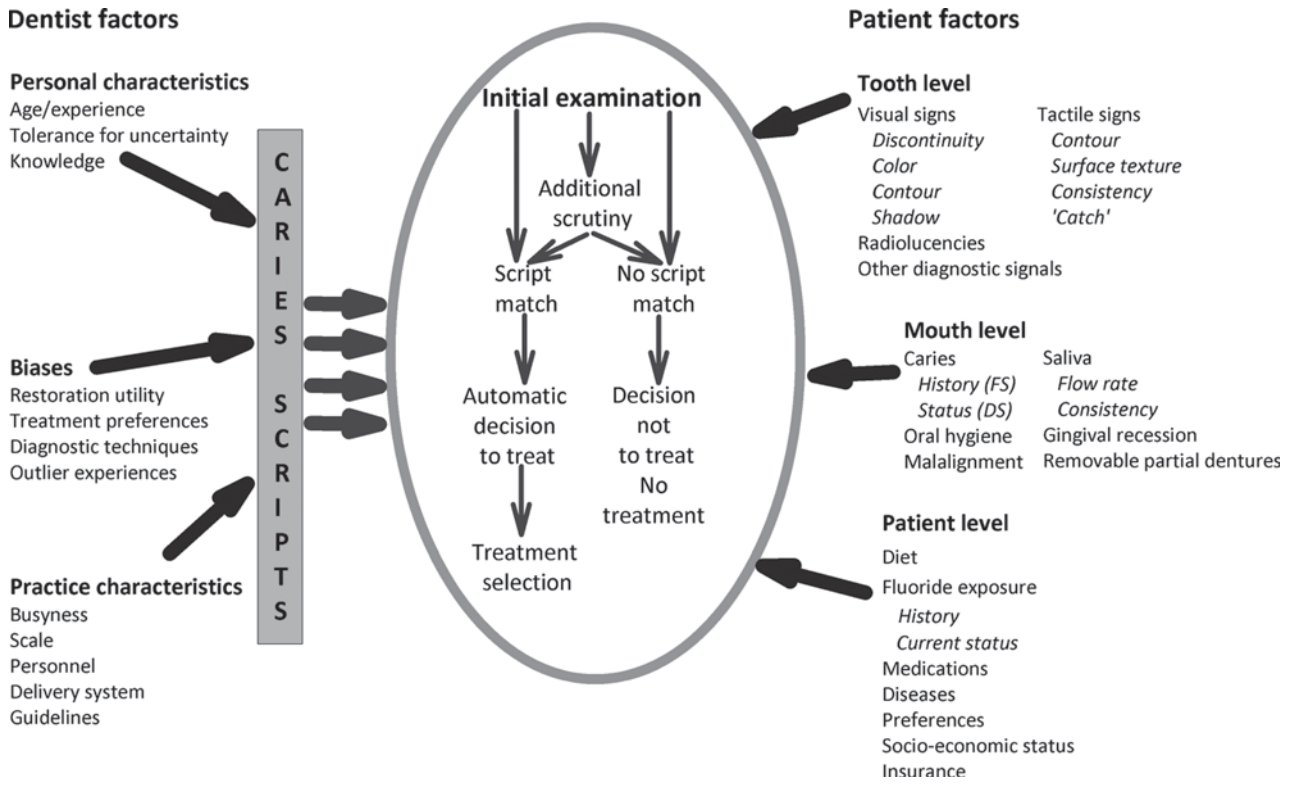

Figure 1. Conceptual model explaining how dentists make caries-related treatment decisions. Adapted from Bader & Shugars [14].

profession embarks on this enterprise. A lot could and should be done at the levels of dental education and the dental faculty [10,14,44]. If the problem is to be solved before dentists become branded as dishonest [46] salesmen [47] who are more devoted to personal income and leisurely living than to their professional obligations [48], we must also address the dentists already in clinical dental practice. By virtue of their position these dental practitioners are strong influences for changes in the caries-related treatment practices of the newly graduated dentist, and may therefore easily undermine/overrule what has been taught at dental school. Unfortunately, established practitioners are most unlikely to change their caries-detection behaviours, and it has therefore been suggested that a single professional standard be developed that minimizes the need for subjective interpretation [14]. While this proposal conflicts with the dental professional's implicit freedom to exercise judgment in their work (i.e. the 'art of dentistry'), it is equally clear that some regulation would benefit the interests of the public.

Finding caries lesions that match our treatment options

Since the clinical caries examination is a lesion-detection process involving 'this-lesion-needs-this-kind-of-treatment' decisions, improvement of our caries-related decisions must begin with an overview of the caries-lesion treatment options that are available to the dental clinician. Step two involves the matching of these treatment options to the different types of caries lesions that may be encountered in the clinic.

Broadly speaking, the caries-lesion treatment armamentarium comprises two distinct forms of treatment: operative and non-operative treatment. While it is recognized that each of these options involves a myriad of alternatives and choices regarding agents and materials, techniques and methods and frequency and dosage, it is also clear that the treatment-decision principles that emanate from these two forms are very simple. Hence, it is generally agreed that a cavitated caries lesion necessitates the insertion of a restoration, the purpose of which is to make the tooth surface amenable to cleansing and to protect the pulpo–dentinal complex [49]. Since cavitated caries lesions may indeed be arrested if they are located in surfaces that are accessible for daily oral hygiene procedures [50,51], the dental clinician may well choose the non-operative treatment route for the motivated patient. Restoring non-cavitated lesions is considered inappropriate since such lesions may be arrested using non-operative procedures [52,53]. Non-cavitated lesions comprise two forms: the arrested and the active caries lesion. There is clearly no reason to institute professional treatment of the arrested caries lesion, whereas it is exceedingly important to be able to control the active non-cavitated caries lesion by non-operative intervention because of an otherwise poor prognosis [54].

The caries-lesion detection process is therefore a matter of detecting caries lesions that match one of these two basic treatment options, and this involves the distinction of cavitated lesions, non-cavitated active lesions and arrested (cavitated and non-cavitated) lesions from the normal appearance of the tooth surface. Only the visual–tactile caries-lesion detection method can achieve this directly. The use of any other caries-lesion detection methods involves assumptions, because these methods are based on physical principles that do not adequately reflect the decisive issues of surface integrity and lesion-activity status. For example, the information provided by bite-wing radiography relates to lesion depth, but there is no unequivocal link between radiographic lesion depth and lesion characteristics in terms of surface integrity, and the bite-wing radiograph provides no information whatsoever related to caries-lesion activity status [55]. The widely held idea that a radiographic lesion extending into dentine is an indication of lesion cavitation has been largely undermined by research in the field [40,56–65], but remains deeply ingrained in the minds of most dental clinicians. It is equally clear that bite-wing radiographs fail to disclose early caries lesions [62,66–70], i.e. precisely those lesions that are amenable to non-operative caries-lesion control. In spite of these reservations, caries-lesion detection in clinical dental practice continues to be based on a combination of (at least) two diagnostic tests: the visual–tactile examination and the bite-wing radiographic examination.

Value of the caries diagnostic test

The value of the caries diagnostic test has most commonly been evaluated by assessing its criterion validity, i.e. by comparing the test result to a histological 'gold standard' [71,72] thought to represent the caries diagnostic 'truth'. However, the de- and remineralization processes involved in caries-lesion formation are dynamic and as long as the resulting net mineral gains or losses stay within limits that do not result in clinically discernible lesion formation or jeopardize the integrity of the tooth, we need not be concerned [10,73]. Moreover, the dynamic nature of the de- and remineralization processes has the additional effect of rendering the 'true' state rather elusive with respect to mineral loss, and the search for a caries diagnostic 'truth' therefore makes little sense [10,73].

Despite the frequent statement that bite-wing radiographs are valuable for caries diagnosis [74] a simple example will reveal how wrong this perception may be. A systematic review [75] concluded that the sensitivity and specificity values for bite-wing radiography in the detection of approximal cavities were 0.66 and 0.95, respectively. Depending on the true, but unknown, prevalence of approximal cavitated caries lesions in the population, the bite-wing radiographic test yields the results shown in Table I. Using the 1% true cavity prevalence as the example, and assuming that the dental clinician decides to restore all the bite-wing radiography-positive surfaces, it may be calculated that a total of 561 (66+495) surfaces will be restored. Among these restored surfaces, 495 (88%) have been unnecessarily restored, i.e. they represent overtreatment. Considering the true cavities, on the other hand, 34 (34%) will remain undiagnosed and thereby undertreated. The total number of decisional errors made amounts to 529 (34+495), and the main result of using bite-wing radiographs for approximal cavity detection is a considerably invasive overtreatment owing chiefly to the less-than-perfect specificity value of 0.95.

The visual–tactile examination has also been evaluated in terms of its diagnostic sensitivity and specificity for the detection of approximal cavities, yielding a sensitivity of 0.52 and a specificity of 0.98 [71]. As shown in Table II, the number of diagnostic errors is much smaller than for bite-wing radiographs, owing to the slightly higher specificity. Using once again the 1% true cavity prevalence to highlight the results, the Table shows that 250 (52+198) bite-wing radiography-positive surfaces will be restored, although 198 (79%) of these surfaces have been overtreated. A total

Table I. Diagnostic results obtained when applying bitewing radiography (BW) for the detection of approximal cavities in a population of 10,000 approximal surfaces. Given for different values of the true, but unknown, prevalence of approximal cavitation. Sensitivity = 66%, specificity = 95% [71].

Cavity prevalence (n = 10,000) (%)	No. of BW+ cavities	No. of BW– cavities	Total no. of cavities	No. of BW+ intact surfaces	No. of BW– intact surfaces	Total no. of intact surfaces
0.1	6.6	3.4	10	585	9405	9990
0.5	33	17	50	497	9453	9950
1	66	34	100	495	9405	9900
2.5	165	85	250	487	9263	9750
5	330	170	500	475	9025	9500

Table II. Diagnostic results obtained when applying visual–tactile (VT) methods for the detection of approximal cavities in a population of 10,000 approximal surfaces. Given for different values of the true, but unknown, prevalence of approximal cavitation. Sensitivity = 52%, specificity = 98% [71].

Cavity prevalence (n = 10,000) (%)	No. of VT+ cavities	No. of VT– cavities	Total no. of cavities	No. of VT+ intact surfaces	No. of VT– intact surfaces	Total no. of intact surfaces
0.1	5.2	4.8	10	200	9790	9990
0.5	26	24	50	199	9751	9950
1	52	48	100	198	9702	9900
2.5	130	120	250	195	9555	9750
5	260	240	500	190	9310	9500

of 48 cavities (48%) will remain undiagnosed and thus undertreated, but the total number of decisional errors amounts to 246 (48+198) and is therefore less than half of the errors committed using the bite-wing radiographs.

The results shown in Tables I and II also demonstrate how misleading is the concept of diagnostic yield. The all-pervading argument in favour of the use of bite-wing radiography for the detection of caries lesions is that thereby more lesions can be detected [10], and it is implicit that the additional lesions detected are real lesions that would have gone undetected had bite-wing radiographs not been used [74,76]. However, as shown in Tables I and II, the additional cavitated lesions detected by bite-wing radiography are largely lesions that are not truly present, i.e. false-positive diagnoses. In fact, considering once again the 1% true cavity prevalence example, the tally shows that bite-wing radiographs lead to correct detection of an additional 14 cavities compared with the visual–tactile examination, but this occurs at the expense of the additional 'detection' of 297 non-existing cavities. Thereby, for each true cavity that has been 'saved' from the perils of going undetected, 21 intact surfaces must suffer the rather deleterious restorative consequences of false cavity detection.

Bite-wing radiographs are usually used as an ancillary diagnostic procedure to the visual–tactile clinical examination, but to the best of my knowledge no studies have looked at the effect of combining test procedures on the treatment decisions made. However, a recent study explored the effects of two different diagnostic strategies in a context conforming with the script-matching caries-detection process [77]. Following a visual examination of each of 96 occlusal surfaces that presented without frank cavitation, each of three examiners was asked to choose between three treatment options: no treatment; non-operative treatment; or operative treatment for each surface. Four weeks later, this procedure was repeated, but this time the examiners had access to the test results from four ancillary tests: bitewing radiographs, electric conductance measurement, quantitative light fluorescence and laser fluorescence. The availability of additional diagnostic information led to a substantial increase in invasive treatment recommendations, considerably more overtreatment and a reduced frequency of correct treatment recommendations [77].

While it may seem counterintuitive to many people that the use of more diagnostic tests does not necessarily lead to better decisions, the phenomenon is intimately linked with the suboptimal reliability and reproducibility of each diagnostic test [40,78]. When tests are added to each other, each of which has a low, but certainly discernible, error probability, the inevitable result is that more diagnostic and hence decisional errors will be made. This simple truth was pointed out by Murphy [79], who noted that whenever diagnostic tests are imperfect (i.e. having less than 100% sensitivity, specificity and reliability), a healthy person is just someone who has not been sufficiently tested. In the dental clinical scenario, multiple testing occurs either as described above, i.e. when several diagnostic tests are applied during the same clinical session, or when a single diagnostic test is applied over a number of consecutive sessions, i.e. semi-annually or annually, as is common practice for patients participating in routine recall/check-up schemes. It is thus a fact that the regular recall/routine dental attendance rates are rather high in many populations [80–89]. In Sweden, 90–95% of adults visit a dentist regularly, and since the 1980s >80% of appointments have been given at the dentist's initiative [80].

Regular dental check-ups—inevitably a good thing to have?

Having regular check-up visits or participating in routine recall programmes should be understood and recognized as participation in regular screening programmes. The principles underlying a screening programme for dental caries are illustrated in

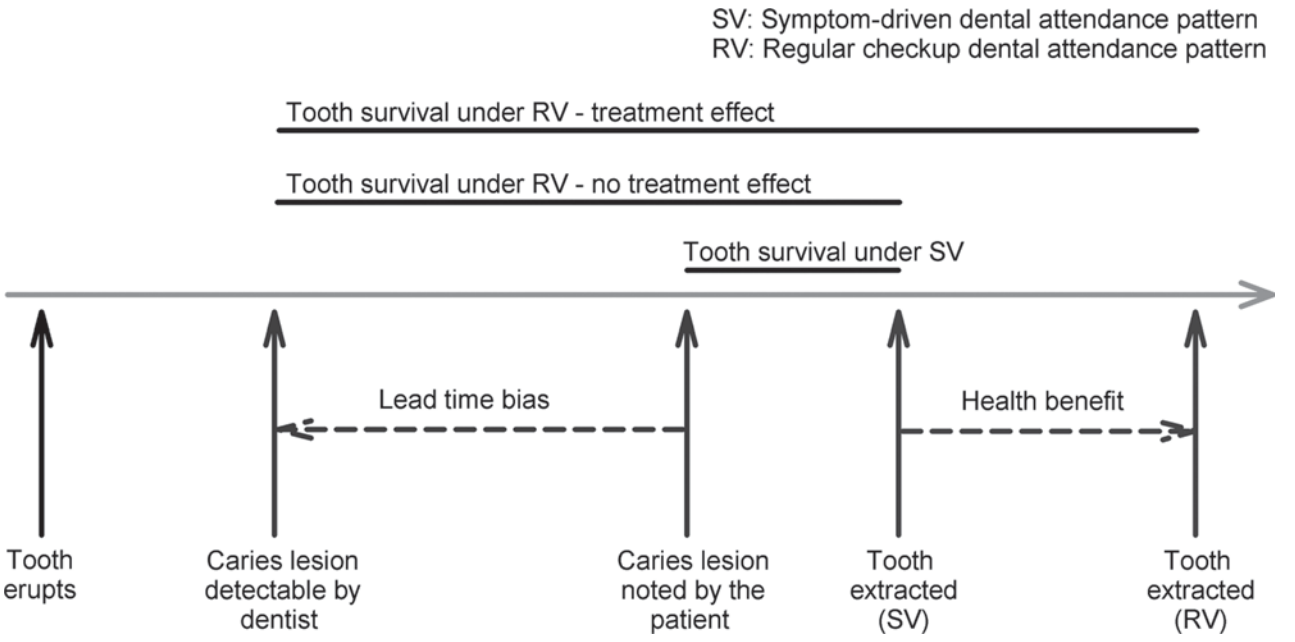

Figure 2. The principles underlining screening: three possible scenarios depending on earlier disease detection and treatment effect.

Figure 2. It is only for illustrative purposes that the unit considered here is the tooth, and the principles can easily be integrated to cover subjects or populations, just as events to avoid other than tooth extraction may be considered. In fact, in many contemporary populations a much more relevant event to avoid would be the first insertion of a restoration. The idea outlined in Figure 2 is that caries lesions can be detected by a dental professional during a routine check-up visit long before the patient would otherwise have noted the lesion. Thereby, the dental professional may institute a treatment of the lesion that may result in increased longevity of the tooth compared with the no-screening situation. However, as Figure 2 clearly shows, earlier detection of the caries lesion is not associated with a benefit to the patient unless the treatment that is instituted leads to postponed tooth extraction (or any other event to avoid). This means that the observation of a longer 'survival time' cannot be taken as evidence of a beneficial effect, but merely reflects the earlier detection of the lesion, a phenomenon called lead-time bias [90].

The claims of benefit made when the dental profession advocates regular dental check-ups can chiefly be described as better oral health conditions (than would have been the case had regular dental check-ups not been carried out). In this context it is noteworthy that the evidence for a beneficial effect of such regular dental check-ups is missing [6,91–93]. The problem is not a lack of studies, but a lack of studies with an appropriate study design. It is thus not difficult to find observational studies that report an association between regular dental attendance and better oral health conditions [81–83,94,95]. However, it is exceedingly difficult to control the biases inherent in such observational studies [6] and the unequivocal evidence should come from high-quality randomized controlled clinical trials. However, such trials are largely missing [6,91,92].

There can be little doubt that dental professionals thrive on the existence of routine dental recall programmes. Moreover, the rather high routine recall attendance rates observed in many countries could be taken to indicate that check-ups are generally very well accepted and considered beneficial by the public, and a layperson might really wonder how could such regular dental check-ups not be beneficial when they are so strongly advocated by dental professionals? However, what the layperson does not perceive—because no-one tells them—is that like any other screening programme, the routine recall or regular check-up dental screening programme may also cause harm. Moreover, the layperson does not know that a profound belief exists throughout the health professions that early (or earlier) disease detection inarguably provides benefits to the screened populations [7]. This professional belief is so profound that screening programmes, such as those for breast cancer, have been launched in many countries in the absence of clear evidence of their beneficial effects [96]. Professionals tend to adopt a paternalistic "we know what is good for you" attitude and may greatly downplay the harmful effects of screening in the information materials that should allow people to decide whether or not to attend based on informed consent [97,98]. In breast cancer screening, it has thus been estimated that if 2000 women are screened regularly for 10 years, one woman will have her life prolonged as a result (that is, she will avoid dying from breast cancer, but may die from other causes), whereas another 10

healthy women will experience harm in the form of unnecessary breast surgery and radiotherapy [96]. In addition, about 200 women (i.e. 10%) are at risk of considerable and sustained psychological distress because they will receive a false-positive breast cancer diagnosis [99,100]. Paradoxically, in the absence of balanced and adequate information given to the person before they decide whether to attend a screening examination, the screened person will react positively to the screening, irrespective of the outcome. The person who was screened negative is happy to know that they are disease-negative (even though this could be a false-negative observation); the person who was screened positive, but in subsequent more detailed tests found to be negative, is relieved again after a period of worry; and the person who was confirmed disease-positive is happy because they have been operated on and saved from a much worse fate (even though this may have been a false-positive diagnosis). This merely shows that in the absence of a fair and balanced account of the benefits and harms of the screening procedure, the population uptake of a screening programme should not be used as an argument for that programme.

Whilst dental caries is in no way comparable to breast cancer, whether as a public health problem or as a personal problem for those affected, the breast cancer example highlights the issues of benefits and harms that should be addressed in any screening programme, including dental routine recall screening programmes. Moreover, in order that members of the public can make informed choices about whether to participate in screening/routine recall programmes or not it is crucial to be open and fair about the intended as well as unintended consequences of participation in the recall programme. If the dental profession is to retain its status as a profession, it is mandatory that it is perceived by the public as being strongly committed to the hallmarks of professionalism, and as clearly denouncing commercialism as a motive.

Patient autonomy and dental professionalism

The high adherence to routine recall visits in the form of annual or biannual dental screening visits may pose a problem from the public's point of view if these screening visits are unnecessary or if the visits are used for selfish professional advantage, e.g. by prescribing unnecessary treatments, which may impair prognosis [101–103], or by ordering unnecessary diagnostic procedures for which the patient must pay. While the patient may to some extent retain control over their demand for the dental services, i.e. the number of dental visits made, by deciding whether to book or honour an appointment or not, it is also clear that they stand much less chance of maintaining control over their utilization, i.e. the costs per visit, once sat in the dental chair. Patients lack the appropriate knowledge and expertise needed to allow them to review their dentist and objectively assess the necessity for and the quality of the work provided [104,105], and this opens the possibility for the dentist to exercise supplier inducement [106–109]. Hence, the evidence shows that dentists are indeed able to control both the demand for [106,108] and the utilization of dental services [106–110]. The public has no choice but to trust that the dentist is not driven by selfish motives when advising and counselling them, and such trust is indeed the centrepiece of the social contract between dentistry and society that has granted dentistry the status of a profession [104,111]. This social contract with society implies that the professionals profess a commitment to competence, integrity and morality, altruism and promotion of the public good within their competence domain [104,105,112–114]. In return, the profession is granted monopoly over the use of its knowledge base in the form of autonomy in practice and self-regulation privileges [112,114].

Dentistry can maintain its status as a profession as long as the public trusts that dentists work for the good of the public and refrain from exploiting their monopoly and the vulnerability of the patients [105]. It is equally clear, however, that a conflict of interests exists between the public and the dentists by virtue of the fact that dentists generate their personal income from the services provided to the public. From an income-generation point of view, dentists who work under a fee-for-service reimbursement system have a vested economic interest in providing more services per patient [105], and the possibility to over-service patients is clearly present. Hence, while each single patient may not pay too much attention to the addition of a diagnostic service to the bill, the dentist is clearly knowledgeable about the implications of so doing for their own revenue.

In recent years, increasing concern has been voiced that dentistry is losing its status as a profession and is changing to become a for-profit enterprise [46–48,115]. Dentistry seems to be increasingly utilizing its monopolistic position to exercise commercialism, and from the point of view of continued public trust in the value of attending the dentist, and participating in regular check-up/routine recall screening programmes, such a change is clearly deeply problematic. Moreover, elective treatments such as cosmetic interventions constitute an increasing proportion of the total volume of dental services provided, but they cannot be considered indicated from a dental health perspective. This intermingling of aesthetic problems with oral health problems poses yet another threat to the status of the dental profession [104].

The rise of commercialism in healthcare and the formation of a healthcare marketplace is not reserved for dentistry, but has been noted in other fields. As an example, Hafferty [116] described the pervasiveness

of medical commercialism by stating that "medicine's traditional 'one or two bad apples' has morphed into a megaorchard of physician clinicians and researchers, brimming with commercial proclivities, penchants, and practices" [116]. Such developments clearly pose a threat to the survival of the core professional privileges, which include discretionary decision making, occupational autonomy and the right to control recruitment, training and credentialing of new professionals. It is thus not difficult to imagine what could be termed a bureaucratic response (Table III) to the onwards march of commercialism within the health professions, in the form of more rules and regulations and codes of conduct and ethics being imposed by the state or insurance companies, i.e. outside the profession. Hence, one of the virtues of the bureaucracy is its ability to serve as a corrective to inappropriate and irresponsible discretion (Table III). Noting that the heart of what professionalism must defend is the economic privilege that follows from professionalism's monopoly over its knowledge base, Freidson [117] predicted that unless current trends are opposed, the professionals are on a course of changing into neutral technical experts serving the needs of state and capital, which will increasingly gain control over performance and costs. Both Hafferty [116] and Freidson [117] noted how the "conspicuous absence of activities conscientiously enforcing professional codes of ethics" has contributed to the vulnerability of the healthcare professions to attacks, and they conclude that the core of professionalism is the devotion to use disciplined knowledge for the public good.

The status of a profession is delegated to a discipline by the state or by capital [117] and is not an attribute that can be achieved unless the state or capital is convinced that the discipline is of special value to the public at large or to an important interest of the state. This delegation is entirely based on trust. Freidson [117] thus noted that "if professionalism is to be reasserted and regain some of its influence, it must not only elaborate and refine its codes of ethics but also strengthen its methods of adjudicating and correcting their violation". This is a call for particular reinforcement of the institutional ethics, i.e. those ethics dealing with the economic, political, social and ideological circumstances that create many of the moral problems of work. If, therefore, dentistry is to survive as a profession, the dental associations have a vested interest in organizing a disciplinary dental practice that exercises responsible and accountable discretion in their decisions, which should be based on evidence. Systems should be devised to vigorously enforce the detailed codes of practice ethics, and dental associations should be seen by the public to take serious action whenever the privileged position of dental practitioners is abused for selfish purposes. Durkheim saw the professions as

Table III. Distinguishing characteristics of three ideal-type models that regulate provider–client relationships: commercialism, bureaucracy and professionalism [117].

	Commercialism (Adam Smith)	Bureaucracy (Max Weber)	Professionalism (Eliot Freidson)
Prototype characteristics	Free market	Civil service organizations	Professions, e.g. law, medicine, dentistry
Type of market	Full competition	–	Monopoly
Purpose	Profit maximization	For the public good	For the public good
Efficiency	High	Moderate	Moderate
Public prestige	Low	Moderate	High
Flexibility and responsiveness	High	Moderate	Low
Organization of work	Perfect freedom	Hierarchy, lines of authority Standardization of procedures	Discretionary judgment, based on abstract theory/concepts, even with manual tasks
Labour market characteristics			
Port of entry	Open	Personnel office (regulated)	Practice institution (closed)
Entry requirements	Consumer choices	Formal job description, by position	Training credentials
Typical career-line	Disorderly, irregular	Regular, vertical within firm	Horizontal, across firms
Predominant knowledge	Everyday	Variable by position, firm-specific	Discretionary, transferable
Consumer/client control			
Degree of control	Full consumer control	No consumer control, control exercised by managers	No consumer control, control exercised by professionals
Autonomy	Consumer autonomy in assessment of utility of goods and services	Moderate client autonomy in utility assessment	No consumer autonomy in utility assessment

the ideal organs for preventing the powerful "from tyrannizing over individuals" [118]. However, the dental profession needs to reassure the public that it is not a cat set among pigeons.

Caries detection in a changing disease panorama

Current developments in oral disease patterns offer an opportunity to test the dental profession's ability to exercise appropriate and responsible discretion. Hence, the epidemiological evidence is overwhelming that the population prevalence, extent and severity of dental caries have declined significantly over past decades, not only in most populations but also in very diverse populations [119–164]. Although the decline has been particularly well documented among children in the high-income populations, the decline is also observed in moderate- and low-income countries, and has clearly also trickled into the adult population groups as well. Concomitant with the caries decline, a considerable improvement has been noted in tooth retention among the older age groups, where tooth loss used to be pronounced.

The data presented by Hugoson et al. [165] from the repeated cross-sectional epidemiological studies carried out in Jönköping, Sweden since 1973 may be used to illustrate how these changes have affected the 'average' dental patient in terms of their caries profile. In Figure 3, the mean dft/DFT counts observed among the Jönköping population have been adjusted to represent all persons rather than dentate persons only. Thereby, the Figure illustrates that, over recent decades, the age at which the dft/DFT experience peaks has moved upwards from 30 years in 1973 to 60 years in 2003. Moreover, the peak dft/DFT experience has declined since the maximum was reached by the 40-year-olds in 1983 (Figure 3). The average dft/DFT experience has shown a steady decline since 1973 among the 10-, 20- and 30-year-olds, whereas the 40- and 50-year-olds show a mixed picture, with caries increases in the early part of the period followed by declines in the later survey years. Among the 60-, 70- and 80-year-olds a gradual increase in the DFT experience is noted (Figure 3), which is paralleled by the increasing tooth retention among these age groups (Figure 4). The cross-sectional epidemiological data presented by Hugoson and co-workers [161,165] thus serve to demonstrate that not only has the caries incidence rate (the number of new lesions per year) decreased substantially, but so has the caries progression rate, and in 2003, 80–90% of all caries lesions observed among the 3–20-year-olds were 'initial' lesions, i.e. non-cavitated caries lesions [165].

The improvements are dramatic and widespread, and it would seem prudent to keep a watchful eye on the extent to which these changes are paralleled by appropriate changes in the dental services rendered to the public. It would thus seem obvious that such dramatic changes should have profound implications for our caries-related clinical decisions. Dentists who wish to subscribe to appropriate dentistry and professionalism will fight their inherent temptation to respond to a biological problem using traditional technical solutions [44], and will increasingly turn in the direction of the non-operative caries management procedures. 'Pre-emptive strikes' in the form of operative (restorative) treatment given to caries lesions for which cavitation status, let alone activity status, is not clinically verified and is only assumed from ancillary diagnostic test results should no longer be regarded as appropriate caries management. The

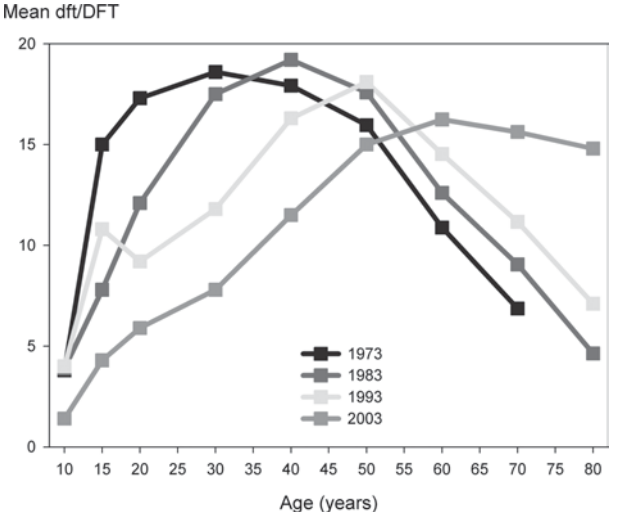

Figure 3. Development over three decades in the dft/DFT counts among Swedes aged 10–80 years. Data from Hugoson et al. [165].

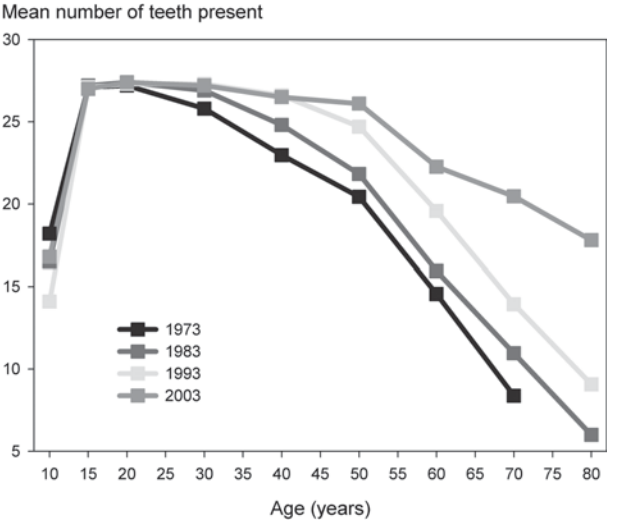

Figure 4. Development over three decades in the number of natural teeth present among Swedes aged 10–80 years. Data from Hugoson et al. [165].

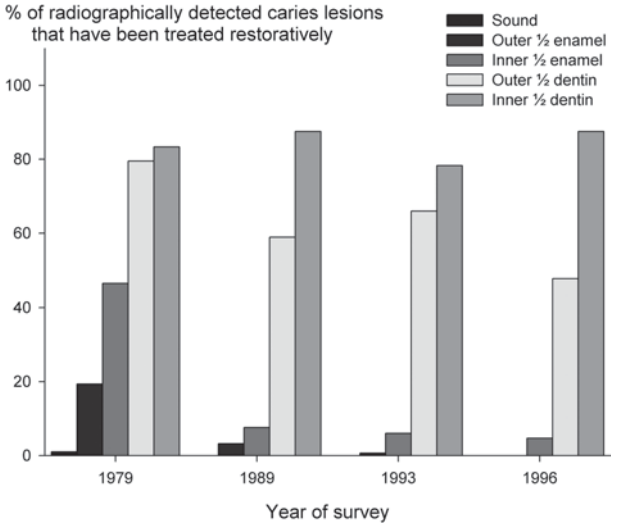

Figure 5. Changes in the propensity of dentists in the Norwegian Dental Public Service to restore approximal surfaces among 15-year-olds as a function of the radiographic finding and the year of examination. Data from Gimmestad et al. [166].

substantially lower caries incidence and progression rates that increasingly characterize the populations imply that restorative treatment decisions should gradually be erased from the dental clinician's caries-controlling armamentarium.

Very little is known about general dental practitioners' responses to the considerable decline in dental caries that has been going on for nearly half a century. However, it is known from both Norway and Denmark that caries-related treatment practices have changed dramatically among dentists employed in the public dental services [166,167]. In Norway, the restorative treatment propensity in 1996 was only 16% of what it had been in 1979 [166] (Figure 5), and in Denmark the restorative treatment propensity in 1984–85 was only 17% of what it had been only 6 years before [167] (Figure 6). In the Danish study these changes were seen as partly resulting from the acknowledgment of slower caries progression rates and a more sceptical attitude towards the results of filling therapy [167], whereas the tentative explanation in the Norwegian study also included a higher dentist workload resulting in non-operative treatments being preferred over operative treatments [166]. It is clear, however, that the responsiveness demonstrated here for public dental services may well have been countered in private dental service settings by the wish to maintain a high income for a reasonable number of working hours. The fact is that dentistry may have arrived at a crossroads. The profession may choose the commercial way, in which case the public must be appropriately informed that dentistry is a for-profit enterprise; or it can choose the professional healthcare-oriented way and respond adequately and ethically to the altered population disease profiles. This involves acceptance that fewer dental services are needed for current users and that more concern be devoted to the underprivileged with whom the major disease burdens will rest in the future [168].

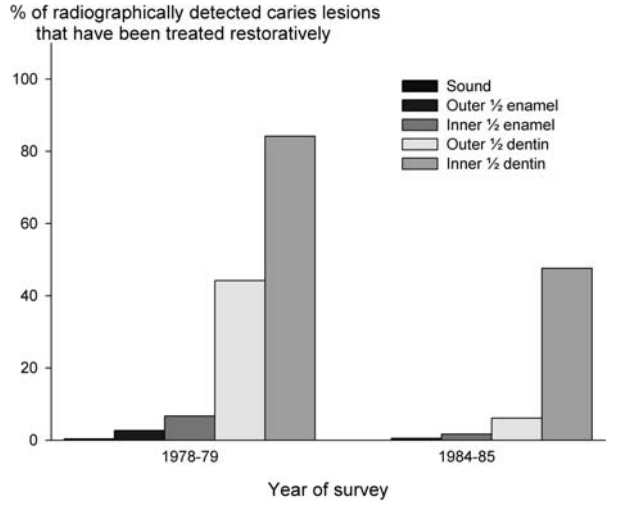

Figure 6. Changes in the propensity of dentists in the Danish Dental Public Service to restore approximal surfaces among 17-year-olds as a function of the radiographic finding and the year of examination. Data from Heidmann et al. [167]

Concluding remarks

Since the early caries lesions that are amenable to non-operative caries treatment are much better detected by means of the visual–tactile examination than by bite-wing radiography [68,169], it would seem timely for the dental profession to place greater reliance on the results of a diligently exercised clinical visual–tactile caries examination and begin phasing out the use of bite-wing radiographs and other ancillary and assumption-ridden diagnostic methods for the detection of 'additional' caries lesions. The visual–tactile caries examination is the centrepiece for the identification of caries lesions that are amenable to treatment based on biologically sound principles, which call for assessment of lesion activity and surface integrity.

The International Caries Detection and Assessment System (ICDAS), which is advertised by some as the new common denominator for modern caries diagnosis in both clinical and research settings [4], is clearly marked by its origin as a tool primarily for researchers and epidemiologists [170]. As such it does not seem to suit the needs of clinicians particularly well. The caries lesion classification employed by ICDAS does not corroborate the script-matching 'this-type-of-lesion-needs-this-kind-of-treatment' type of decision making used by dental clinicians [13], and does not consider lesion-activity assessment. Moreover, to achieve lesion-activity assessment in the ICDAS system, points must be assigned to the caries lesion scores based on assessment of plaque

stagnation characteristics and surface texture, and the total number of points is used to determine the activity status [171,172]. From a strictly procedural point of view this caries-lesion detection system therefore seems to have limited applicability in a dental practice setting, where countless caries-related scripts are matched on a daily basis.

Since appropriate caries treatment selection simply necessitates a distinction between active and arrested, and between cavitated and non-cavitated caries lesions, the criteria employed in the visual–tactile caries examination should focus on two aspects: activity status and cavitation status. In this respect, the Nyvad criteria [78,173] are clearly best suited for use in clinical dental practice settings. They are simple to use and provide a direct link between the best treatment options available and the clinical presentation of the lesion in question. Thereby, these criteria fit well with the script-matching procedure used daily by dental clinicians worldwide to make clinical caries-related treatment decisions.

Much continues to be written about the relative merits of various caries diagnostic approaches in terms of their validity and reliability/reproducibility profiles. However, at the end of the day the best caries diagnostic test is that which results in the best long-term oral health outcomes for the patients. This means that it is not sensible to attempt to separate diagnostic decisions from treatment interventions, because it is the treatments and not the diagnostic procedures that can make our patients fare better than they would have done under different circumstances. Thereby, the 'gold standard' test for caries diagnostic methods is the randomized controlled clinical trial, because this is the only type of investigation that can validly provide the answer to the crucial question: which method of detecting caries lesions for treatment provides the best long-term oral health outcomes for our patients?

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