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Dental Caries: Black to Dental Update and Beyond!

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Abstract

Dental Caries is one of the most common non-communicable diseases globally and whilst entirely preventable it still accounts for a huge economic burden in the form of operative management which ranges from minimally invasive techniques to extensive direct and indirect restorations, root canal treatment and ultimately extraction. In this paper we look at the marked changes in caries epidemiology, detection, diagnosis, assessment and management that has taken place in the last five decades since Dental Update was first published and reflect on how this has impacted upon the oral health of our patients today.

CPD/Clinical Relevance: Awareness of changes in Caries understanding over the last 5 decades.

When the first edition of dental update was published in 1973 the ages of the authors were 11, 9 and 3 years old! In 1973 the oral health of children was quite different to that of today and could only be regarded as poor.[1] Our individual dental health prospects as children back then appeared to be challenging and unknown to ourselves at the time, so were our career paths as Dentists, Specialists in paediatric and restorative dentistry and researchers in cariology. In this paper we will look at disease trends and the challenges we have faced to date.

Child Dental Health

In 1973 coincidently, the first national survey of children's dental health in England and Wales was carried out and has been every 10 years since, informing the government and profession about disease trends and allowing to plan for healthcare needs. In 1973 and for the ensuing three decennial surveys, all four constituent countries of the United Kingdom were involved in data collection. Since 2013, however, with devolved governments individual Countries have reported

separately making analysis and reporting more complex but not impossible – the thin edge of the devolution wedge!

In 1973 the children examined in the Child dental health survey were born before the widespread introduction of fluoridated toothpaste in the early 1970's, as a result the average number of decayed, missing and filled teeth (DMFT) in 15 year old children at the time was high (DMFT = 8.4) with 97% of children having some decay and for 5 year old children the mean dft was 4 with 72% having some decay.[1]

By the time the second Children's Dental Health Survey had been carried out all of the 5 year olds' and all of the 15 year olds' permanent dentition could have benefited from topical fluoride in tooth pastes and the 1983 survey showed a significant decline in dft in 5 year olds to 1.8 with 20% fewer children having caries. Whilst for 15 year olds the average DMFT fell to only 5.9, with 92% still having evidence of caries. The reduction in caries prevalence seen in 5 year old children thereafter appeared to level out. For 15 year olds it took longer to see a marked decline in caries experience with the 1993, 2003 and 2013 children's dental health surveys showing DMFT's of 2.5, 1.6 and 1.2 and 63%, 49% and 42% of children with caries respectively.

With this decline in caries prevalence in the United Kingdom the disease presentation within the population became increasingly more skewed according to socio-economic status and deprivation. Take Figures 1 for example, this clearly shows that for 5 year olds in Scotland those that were in least affluent families had higher disease prevalence ($d_3$mft (A)) and fewer children were caries free (B).[2] This data also showed that children from least affluent areas were more likely to have teeth extracted and more teeth with untreated caries compared with their counterparts from more affluent areas. With such a significant difference in disease presentation there was a clear need for health care policy to address these inequalities.

Adult Dental Health

The first survey of adults, their dental attendance patterns, attitudes toward their oral health and actual dental health was carried out in the UK in 1968, 20 years after the introduction of the National Health Service in 1948. The lack of fluoride in toothpastes, lack of oral health awareness and knowledge, and the impact this had on this generation of adults was all too obvious to see and by todays standard was shocking. On average 37% of adults were completely edentulous, with a marked variation between the more affluent South East of the country (28% edentulous) and the more deprived North (46% edentulous). Obviously, this was not solely due to dental caries, and other factors were likely to have impacted on the level of edentulousness, namely periodontal disease, dental attendance and patients' attitudes to retaining teeth to name but a few.[3] However, improvements in the aforementioned factors saw the level of edentulousness drop dramatically to just 6% of the adult population by the time of the 2009 survey.

Whilst the data from the first Adult Dental health survey available when the first edition of Update was published, allowed the basic oral health trends detailed above to be measured, data collection in the 1978 survey and onwards was carried out in greater detail allowing caries trends specifically to be measured. Trends in decreased caries prevalence were also seen in adults over more recent surveys, for example the average number of decayed teeth has dropped from 1.9 in 1978 to 1.1 in 1998[4] and 1 in 2009[5]. However, in the 2009 survey 29% of people had decay in the crowns of one or more teeth, again showing the skewed distribution of caries in the population, with the minority (29%) having the majority of disease (high level disease to bring average number of carious teeth in the whole adult population up to 1).

Disappointingly the oral health of adults has also been shown to be linked with social deprivation, a consistent pattern which can only be made worse with the way in which dentistry is funded in the UK. Little emphasis and renumeration is given to prevention and it is therefore no surprise that the 2009 survey showed low levels of preventive care given to patients by their oral health care

providers. Cost was also cited as an ongoing barrier for access to care, which in the current economic crisis is a disaster in the making.

Disease trends and impact since 1973

As a dental student in the early 1980's the lead author remembers sitting in a lecture theatre at Guy's Hospital Dental School and being shown a graph similar to that in Figure 2. It clearly illustrates the decline in caries prevalence in 12 year old children throughout a number of European Countries and the potential decline in demand for dental care. This together with other factors led to the premature closure of three undergraduate dental schools in the United Kingdom; Firstly, the Royal Dental Hospital, Leicester Square in 1985, University College London Dental School in 1991 and finally Edinburgh Dental School in 1994. At the time, this led to a strong backlash from the dental profession as access to NHS dental care was a problem then[6] which has only escalated to crisis point now with only 9% of dental practices in England accepting new NHS adult patients and 21% accepting child patients. The COVID 19 pandemic has compounded the problem of access with many dentists now leaving the NHS due to demand and a funding system in England that is not regarded as fit for purpose[7].

The series of adult dental health surveys has shown that more adult patients are retaining their teeth into older age, these teeth are becoming increasingly restored and the types of restoration are becoming more complex with more advanced treatment needs resulting from caries and tooth wear. With this increased restorative care comes an increased need for more intensive preventive programs, maintenance and repair in addition to replacement restoration due to caries which remains a constant problem throughout the age groups (29% consistently having caries across all the adult age groups). Demand for treatment is therefore high and access to care derisorily low.

Caries diagnosis: the Epidemiologist and the Clinician

Prior to the 1998 Adult Dental Health survey and the Child Dental health survey in 2003, caries was only recorded at a cavitation level and because multiple examiners were employed in these surveys standardisation and calibration of the examiners was undertaken. This allowed comparisons across different sites (examination centres) and examiners, and at different time intervals so that disease trends could be monitored over time and across borders. However, to facilitate this a standardised blunt probe 0.7mm in diameter for the Adult Dental Health survey[8] and 0.4mm in diameter for the Child Dental Health survey[1] was used to confirm cavitation which allowed the entrance of the probe.

When does cavitation take place?

Cavitation occurs at a late stage in the disease process on both the occlusal and proximal coronal surfaces. Take the occlusal surface for example (Figure 3), where, due to the invaginated anatomy of the fissure early lesions occur just at the entrance to the fissure or on the fissure walls. These lesions if left unchecked by prevention can progress into dentine on either side of the fissure, merging at the base of the fissure and advancing into dentine on a much wider front. It is also thought that topical fluoride now makes the occlusal enamel harder and more resistant to collapse (cavitation) above extensive dentine demineralisation (Figure 4). Often such lesions would be missed on a clinical examination but were deep enough to be detected radiographically and this apparent phenomenon in the early 1980's was termed "hidden caries", "occult caries" or "fluoride caries".[9]

On the proximal surface, numerous studies comparing the radiographic appearance of proximal lesions and the prevalence of cavitation has shown that only 25% of lesions radiographically up to the enamel dentine junction and deeper clinically were cavitated and even about a third (31%) of lesions extending radiographically into the outer half of dentine had non-cavitated surfaces[10].

Take the above argument on cavitation and consider the conditions in which such National Surveys were carried out, on uncleaned teeth often covered with an acquired pellicle and plaque biofilm,

viewed wet and illuminated with a headlamp and it is clear that the level of disease estimation was a gross underestimate. The epidemiologist at the time would argue that caries diagnosis at the cavitation level would however still allow for disease trends in a population to be measured. The clinician on the other hand is completely different and would aim to diagnose caries at a much earlier stage so that prevention could arrest the lesion and prevent the need for a restoration.

Recognising the importance of diagnosing caries at a stage before cavitation led to a change in criteria for caries recording for both the Child Dental Health and Adult Dental Health epidemiologist from 2003 and 1998 (respectively). From this time forward any "visual evidence" of caries including enamel caries was recorded bringing the survey data more into line with clinicians' expectations.

Caries diagnosis vs detection

Prior to the first Dental Update most dental publications referred to caries diagnosis. A PubMed search up to 1973 using the terms "caries" "diagnosis" revealed 967 articles compared to only 27 for "caries" "detection". The term "diagnosis" was used very loosely then and it has since been recognised as a much more complex process than purely caries detection or the identification of a lesion.[11] The clinician takes into consideration many factors consciously and/or subconsciously such as the extent of the lesion, patients' caries risk factors and whether the lesion is active or not. It is the complex assimilation of all these factors that enables the clinician to make a true diagnosis and formulate a patient-focused care plan.

Changes in caries detection methods

Traditionally caries detection was regarded as difficult with just a visual examination; on the proximal surface an adjacent tooth makes direct vision impossible and the invaginated anatomy of the occlusal surface often "hid" extensive lesions. The latter led clinicians to use a sharp explorer to assess pits and fissures for "stickiness" in the time honoured GV Black technique (1936)[12]:

> *"The point* (of an explorer) *should be applied with some pressure and if it enters the enamel a little, so that a very slight pull is required to remove it, the pit should be marked for restoration, even though there is no sign of decay"*

In the mid 1950's it was soon recognised that "stickiness" may only reflect the fissure morphology or the pressure exerted on the probe![13,14] More recent laboratory work has also shown that caries into dentine was frequently missed using this "tactile technique" and added nothing to diagnostic capability of a purely visual examination.[15,16] Bearing this in mind together with evidence that probing pits and fissures leads to irreversible traumatic defects in demineralised areas[17,18] and a subsequent increased rate of further demineralisation[19], it is disappointing that this "antiquated art" has been too slow to eradicate considering it has long been regarded as obsolete.[20]

Development of new/novel detection methods

The perceived difficulty in early caries detection (particularly on the occlusal surface), allowing for targeted prevention and subsequent monitoring of lesions over time has led to extensive research into improving existing technology and development of new and Novel detection methods.

Dental radiography has been the mainstay supplemental caries detection method for over a century but has undergone radical advancement in the last 50 years.[21] In relation to intra-oral radiography, improvements in image detectors/sensors have been marked and range from increasing speeds of conventional radiographic film to the development of digital intra-oral sensors which have both allowed for a reduction in radiation exposure to the patient without deterioration in diagnostic accuracy. Whilst dental radiographs are a way in which lesion progression can be monitored over time on the approximal surface, the radiographic technique has to be highly reproducible and it should be borne in mind that it is not highly sensitive for early caries detection[22].

Novel caries detection techniques that have been developed include electrical conductance methods[23], other optical methods such as fibre optic transillumination[24] and laser fluorescence

techniques.[25,26] Some of these have led to the manufacture of commercially available devices which can detect caries at an earlier stage and quantify the severity of caries with objective measurements. However, none have gained universal acceptance, perhaps because of the extra cost and time involved to use them and a lack of high-quality evidence to promote them, with the majority of research being carried out on extracted teeth in the laboratory and so questioning the transferability into clinical use.[27]

The lead author should put his hand up at this stage and admit that his PhD was indeed on electrical conductance methods for caries detection and proudly presented his research at an ORCA (European Organisation for Caries Research) conference in Noordwijkerhout, The Netherlands in 1995, only to be challenged by a colleague that it really wasn't necessary. The perceived difficulty in visual detection of caries was because teeth were more often than not examined in an uncleaned state and often wet, and that what was seen was not related to the histopathology of the disease. Work with this colleague and now friend led to the development of a visual classification system[28] which related the visual appearance of a lesion to its histological depth. The importance of cleaning teeth prior to examination and viewing teeth both wet and then dry enabled the severity of early enamel lesions to be differentiated. This early classification system was further refined and developed into the International Caries Detection and Assessment System (ICDAS criteria).[29] Lesion activity and caries risk assessment was subsequently included, which enabled this caries assessment system to be linked to an appropriate patient centred caries management system, the International Caries Classification and Management System (ICCMS)[29] and subsequently the CariesCare plan for use in general practice.[30]

Caries Risk / Susceptibility

Caries risk / susceptibility has been defined as *"the probability that an individual will develop one or more carious lesions reaching a given stage of disease progression during a specified period"*[31] and caries risk factors are those that are known to be associated with the development of caries over

time. By the time the first Dental Update was published in 1973, caries risk and patient risk assessment had not featured in the dental literature and as a result perhaps not given as much credence as it should have been in clinical practice. However, by the turn of the century (2000 onwards) that changed and there was a dramatic rise in interest, understanding, acknowledgement and resultant publications on caries risk.

The interest in caries risk / susceptibility led to the development of various assessment systems that could categorise patients into low, medium or high risk groups. These include the Caries Risk Assessment Tool proposed by the American Academy of Pediatric Dentistry (AAPD), the Caries Management by Risk Assessment Philosophy (CAMBRA)[32], the Cariogram[33] and more recently the CariesCare International (CCI™) Practice Guide[30] to name but a few. These systems take into account various risk factors, weighting them and their interactions to determine a patient's risk of developing caries in the future and hence allowing targeted prevention or care plan tailored for each individual patient. Despite extensive research on the earlier models of caries risk assessment, systematic review of the literature has shown that evidence for the validity (do they do what they purport to do) of these systems is limited.[33]

This having been said, the Cariogram remains an excellent visual tool for both clinician and patient to illustrate and quantify a patient's level of risk expressed as the "actual chance to avoid" new caries lesions (Figure 5). This system considers the main caries risk factors seen on the right and scores them from low risk (n=0) to high risk (n=2 or 3) for each patient. For example, diet frequency considers the average number of meals/snacks a patient has per day, **score 0** = maximum of 3 meals/day through to **score 3** ≥7 meals per day and fluoride program considers the extent of fluoride exposure with **score 0** reflecting maximum fluoride exposure (additional measures over and above over the counter toothpaste) to **score 3** reflecting avoidance of fluorides. As long as seven risk scores are entered a Cariogram will be generated. Figure 6 shows a Cariogram for a high risk patient (high caries experience, diet high in sugar and frequency of intake, poor oral hygiene and use of fluoride

toothpaste only) with only a 12 % chance of avoiding new carious lesions in the future. This Cariogram can be used as an educational tool for the patient who on advice from their oral health care professional can address the risk factors. The Cariogram can then be repeated at recall to reassess on-going caries risk. Figure 7 illustrates what can be achieved by doing this and the patient's caries risk has change to a 58% chance of avoiding new caries in the future. The Cariogram can be down loaded for free on the Malmö University website or the App. A more detailed review about the need and validity of caries risk / susceptibility assessments can be found in the following recent textbook by Twetman and Banerjee (2020).[34]

Lesion activity

Ideally once a carious lesion has been detected and its severity assessed, it is important that the activity of the lesion is determined, that is, is it likely to progress with time (active) or is it arrested (inactive) and unlikely to progress. This is important because active non-cavitated lesions and patients require targeted preventive management. Like caries risk assessment, lesion activity assessment is the "holy grail" of cariology!. The only true way to determine if a lesion is active or not is to monitor it over time and see whether it has progressed or not, but this is often too late. The clinician ideally would want to determine lesion activity at one point in time. As for caries risk, interest in caries activity assessment has increased over the life span of Dental Update.

In the mid 1980's enamel lesion activity and characterisation were investigated using spaced orthodontic bands placed on premolar teeth due for extraction for orthodontic reasons.[35,36] The spacing allowed for plaque accumulation and the development of enamel lesions. After 4 weeks the bands were removed and the classic white spot lesions created were obviously active and were found to be matt in appearance and rough to a probe drawn across its surface. However, in the following 4 weeks of regular oral hygiene procedures the lesions underwent some surface

erosion/abrasion and remineralisation, resulting in inactive lesions which had become glossy in appearance and smoother to a probe.

This classic characterisation of active and inactive enamel lesions continues to be used alongside other visual tactile classification systems. Whilst it is the best we have currently it should be borne in mind that such assessment may be a lot easier for large provoked lesions under a spaced orthodontic band. Assessment of more subtle changes in smaller naturally occurring lesions has been shown to be much more difficult, less reproducible and less accurate.[37,38] The largely unmet need for reliable caries activity assessment has prompted a group of researchers from King's College London to investigate a novel approach to detect released calcium from active lesions by virtue of a technology that uses a luminescent protein – the Calcivis System[39]. Its continued development may indeed see it as an adjunct to dental caries activity assessment and monitoring of prevention in the future.

However, care must be taken. In striving to gain accurate measures of lesion activity at an earlier and earlier stage, one has to keep in mind the overall clinical relevance for patient benefit, of such data. How is this data going to alter clinical practice for the benefit of patients? Will preventive advice change? For research purposes, this data is indeed interesting but the desire in society to collect terabytes of data without ultimate benefit, must not go unchallenged.

Operative caries management

Of course caries management should be driven by risk / susceptibility assessment, early detection, targeted prevention and monitoring, but for some the reality is that operative caries management is required. At the time Dental Update was first published, little if anything had changed since the teaching of GV Black in the early 1900's. The decision to treat carious lesions was often at an early stage (prior to cavitation) when caries appeared or was thought to have reached the enamel-dentine

junction (EDJ). There was also a great variation in treatment threshold between clinicians, often leading to a significant difference in treatment plans for the same patient.[40] Better understanding of the disease has hopefully improved this situation with better guidance through management pathways as to when to restore a carious lesion and management with minimally invasive, tooth-preserving techniques.[29,30]

Once the decision to treat a carious lesion operatively had been made, the biggest change afoot has been in relation to how much caries we need to remove. Renewed interest in caries removal has taken place over the last two decades and is moving away from a purely mechanistic, surgical approach to one that is based more upon the microbiology and histopathology of the lesion in dentine.

Historically caries removal and cavity preparation were extensive. GV Black (1936)[12] wrote that "*Generally when the cavity has been cut to form, no carious dentin will remain"* and that *"it is better to expose the pulp of a tooth than to leave it covered only with softened dentine."* Once completed, the cavity was further modified, extending the cavity margins into cleansable areas beyond the contact points and running susceptible occlusal fissures out before restoration – the so called "extension for prevention" philosophy.

In the mid 1970's through to the mid 1980's this philosophy was challenged with Fusayama and colleagues (1980)[41] describing two zones of carious dentine differentiated by a caries detector dye. The two zones were the "inner zone" or "caries-affected zone" at the advancing front of the lesion closest to the pulp, and the "outer zone" or "caries-infected zone" closer to the tooth surface. In the inner zone the dentine was demineralized (by the acid produced by cariogenic organisms in the outer zone diffusing toward the pulp), the collagen was intact and the dentine less infected with bacteria, whilst in the outer zone the dentine was more severely demineralized, the collagen denatured and heavily infected with cariogenic organisms. The significance of these two zones was that it was no longer thought necessary to remove all remnants of carious dentine and only the

outer zone required removal, leaving the inner zone which was often darkly stained and firm or leathery to a probe. The introduction of newer dental materials capable of creating a hermetic seal with tooth tissue also saw a dramatic change in cavity design, with the cavity outline being dictated purely by the extent of caries[42].

This change in strategy started a revolution and prompted clinicians and researchers to question the need for such radicle caries removal and indeed if dentine caries needed to be removed at all if caries could be sealed into the tooth with modern adhesive dental materials.[43] Studies that investigated this include those in which:

- No dentine caries was removed:

  Fissure sealant studies – occlusal lesions in permanent teeth visible on bitewing radiograph, and likely to extend into the middle third of dentine, are simply fissure sealed.

  Hall technique – extensive cavitated lesions in primary teeth have been treated by cementing a preformed stainless steel crown with a glass ionomer cement.

- An ultraconservative caries removal technique was used:

  Occlusal lesions in permanent teeth visible on bitewing undergo widening of the fissure to remove carious enamel, but no dentine caries removal takes place. This is then restored with composite.

- Caries was removed in two stages (stepwise excavation)

  In deep carious lesions where there is a risk of exposing the pulp, caries is removed over two visits 6 to 12 months apart:

  Visit 1 Access to dentine caries gained and the periphery of the cavity (at the EDJ or outer 1-2 mm if on root dentine) rendered completely caries free but leaving frankly soft carious dentine over the pulp and a provisional restoration (e.g. glass ionomer or composite) is placed.

Visit 2 6 to 12 months later the provisional restoration is removed and the residual caries pulpally undergoes selective caries removal to firm/leathery dentine.

- Partial caries removal or selective caries removal to soft carious dentine pulpally

  This is essentially Visit 1 management in stepwise excavation without re-entering.

These studies have consistently shown that sealing soft dentine caries into the tooth deprives the cariogenic bacteria entombed from sugar substrate and prevents further colonisation, leading to a dramatic decline in viable organisms and biodiversity, essentially arresting the caries process and allowing time for protective pulp – dentine complex reactions (tubular sclerosis and tertiary dentine) to take place. This leads to a significant reduction in risk of pulp exposure and pathology and no deterioration in restoration retention. Considering the poor long term prognosis of a direct pulp cap which is most often used following a carious exposure of a vital and minimally inflamed pulp, there are considerable biological and financial benefits to be gained in using these selective caries removal techniques.[43,44]

Translation of research into clinical practice.

Despite the evidence for the use of minimally invasive selective or partial caries removal and the clinical benefits, there appears to be poor uptake in primary care practice.[45] The reasons for this are varied and complex and may involve issues such as the method of renumeration, fear of leaving caries behind, in that it may progress in an uncontrolled manner, failure due to pulp pathology, fear of litigation and fear that colleagues may regard this as substandard treatment to name but a few. These reasons are however gradually being overcome.

It is true that the majority of studies on less invasive caries removal techniques involve small numbers and are carried out in secondary care settings and /or by dentists or specialists with an

interest in the techniques. This may also be behind the lack of acceptance in primary care – "it won't work in the real world" scenario! In addition, as dentists we may believe our patients will not be accepting of such an approach. But how often have patients had a say on such techniques and research protocol? Sadly, the answer is "hardly ever". But this has changed in recent years and Personal and Public Involvement (PPI) is an important aspect of any clinical research. Patients and patient participants are now placed at the forefront of clinical trials and work in partnership with researchers rather than simply a subject!

It is these factors that have led to an NIHR HTA funded randomised clinical trial being carried out in NHS primary care practices with all stake holders (researchers, dentists and patients) involved: the SCRIPT trial (Selective Caries Removal In Permanent Teeth).[46] This trial is being led by the Universities of Dundee and Aberdeen and involves collaborators at the University of Sheffield and Kings College London and is comparing selective or partial caries removal with complete or near complete caries removal. This is an exciting opportunity to carry out high quality research that has a huge potential to change how dental caries is operatively managed in the future. The SCRIPT trial is still on going and to find out more information and possible involvement scan the QR code at the end of this paper or contact the main trial office at script@dundee.ac.uk

We have learned from the past and this paper outlines the evolution of caries management over the last 50 years. The profession, with clinical academic evidence, should and is beginning to move on from the dental surgeons' "drill, fill and bill" philosophy of care to the oral physicians' more prevention-based management pathway – minimum intervention oral healthcare (MIOC – see Figure 8)). The future of delivering better oral health and caries management must be patient-focused and team-delivered, using the scope of practice of all members of the oral healthcare team. Patient behaviour modelling has become paramount in the successful long term management of one of the most prevalent non-communicable, life-style related diseases affecting humankind. Primary preventive non-operative measures include diet control, optimal oral hygiene procedures and the

use of fluoride and other topical mineralising agents, carried out by the patient at home. Secondary prevention with micro-invasive sealants and infiltration techniques to arrest and reverse early lesions are advocated and where patients present with cavitated carious lesions, minimally invasive operative dentistry (MID) is recommended.[47-52]

It is interesting to look back at Cariology over the last 50 years of Dental Update and the challenges and changes that have occurred. This publication we hope has highlighted some of the more significant ones. Dental Update even ran a series of publications in the late 1980's entitled "Dentistry in the year 2000", reflecting on the changes in the first decade of Dental Update and postulating on how things may look in the next decade and beyond. One Dental Update Editorial Board member, Professor Edwina Kidd, wrote one of these and posed the question "Dental Caries: Problem Solved?"[53] This paper concluded that the dental professionals were working in "challenging times" and that "the problems of dental caries were far from" being solved. It is sad to reflect that perhaps the same conclusions can be made today, some 40+ years later. The way in which dentists are renumerated and the COVID 19 pandemic has compounded these challenges, making access for patients to dentists more difficult and the distribution of disease in the population as skewed as ever over the socio-economic groups. The need for innovative preventive programs such as the Child Smile program in Scotland to improve dental health in all age groups and address inequalities is as important now as ever before. Research and adoption of new minimally invasive dental techniques in the future may also address issues of access, standard of care, quality of life and environmental sustainability. It will be interesting to see how the cariology land lies in the next 50 years!

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Legend to Figures

Figure 1 The relationship between social deprivation categories (DEPCAT Score) and the percentage of the population who have dentine caries, missing or filled teeth ($d_3$mft) (A) and percentage caries free (B). The most affluent score 1 and least affluent score 7 (Data from Sweeney et al., 1999 for 5 year old children).[2]

Figure2 Caries prevalence for 12 year old children in various European countries according to year of survey (for illustrative purposes only).

Figure 3 Radiograph of a section through an occlusal fissure in a molar tooth. The occlusal surface and fissure, and enamel dentine junction are outlined. Two early enamel lesions can be seen as radiolucencies on the walls of the fissure (arrowed).

Figure 4 Occlusal view of an upper molar showing a non-cavitated enamel (brown spot) lesion at the entrance to the fissure (A). The hemisected tooth shows extensive caries into the middle of the dentine (B).

Figure 5 Cariogram home page showing risk factors on the right-hand side.

Figure 6 Cariogram of a high risk patient (high caries experience, diet high in sugar and frequency of intake, poor oral hygiene and use of fluoride toothpaste only) with only a 12 % chance of avoiding new carious lesions in the future.

Figure 7 Cariogram for fictitious patient seen in Figure 6 showing how improvement of diet (frequency and sugar content), oral hygiene and use of supplemental fluorides can change a patients risk. The patient now has a 58% chance of avoiding new caries in the future.

Figure 8 The contemporary patient-focused minimum intervention oral care (MIOC) delivery framework showing the four interlinking clinical domains of *identify* - clinical assessment / diagnosis; non-operative, micro-invasive *prevention* of lesions / *control* of disease; *minimally invasive* operative intervention; and *re-assessment* (recall / review / active surveillance). The arrows indicate the

direction of the patient pathway through this care delivery framework and within each domain an indication is given of the members of the oral healthcare team who might be involved (GDP – general dental practitioner; DCP – dental care professionals (includes oral health educators, extended duties dental nurses (EDDNs), dental hygienists, dental therapists, practice managers, clinical dental technicians, reception staff)).

SCRIPT QR code