Rationale for restoration of carious primary teeth: a review

Précis

The literature regarding the dental and systemic effects of early childhood caries, the consequences of leaving carious primary teeth untreated, the benefits of appropriate treatment, and concerns regarding dental treatment of young children and the potential for dental anxiety, is reviewed.

Abstract

Early childhood caries (ECC) has consequences, affecting both the child's dental health and his/her general health.
This paper reviews the literature regarding ECC and its consequences (pain, sepsis, space loss, disruption to quality of life, failure to thrive, effects on intellectual development, greater risk of new carious lesions in both primary and permanent dentitions, higher incidence of hospitalisation and emergency visits, and increased treatment costs and time). The effects of treatment of ECC are also reviewed, and concerns regarding purported associations between treatment of ECC and dental anxiety are addressed.

Search method

A PubMed search was conducted of peer-reviewed papers published in the English language in the years 1986-2011, using the search terms: early childhood caries (ECC); nursing caries (NC); consequences and ECC/NC; treatment and ECC/NC; treatment outcomes and ECC/NC; dental anxiety; dental fears; onset of dental anxiety/fear; and, dental experiences and dental fear/anxiety. More than 300 articles were studied. Reference lists of the selected articles were also studied, and frequently quoted articles were thus also located. Articles with small sample size, poor or poorly described methodology, and unclear or unsupportable conclusions were rejected. A representative sample is presented in this paper, citing the articles with greater levels of evidence, with a description of study methods, where appropriate.

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Table 1: Possible effects of early childhood caries

Effect of ECC	References
Pain	Levine RS, *et al. Br Dent J* 2002[4] Shepherd MA, *et al. Br Dent J* 2002[12] Milsom KM, *et al. Br Dent J* 2002[13] Slade GD. *Community Dent Health* 2001[14]
Sepsis	Pine CM, *et al. Br Dent J* 2006[15] Unkel JH, *et al. Pediatr Dent* 1997[16] Lin HW, *et al. Clin Pediatr* 2009[17] Davies RG, *et al. Clinical Intensive Care* 2002[18]
Space loss	Northway WM. *J Am Dent Assoc* 2000[20] Laing E, *et al. Int J Paediatr Dent* 2009[21] Lin YT, *et al. J Clin Pediatr Dent* 1998[22] Rao AK, *et al. J Indian Soc Pedod Prev Dent* 1999[23] Padma Kumari B, *et al. J Indian Soc Pedod Prev Dent* 2006[24] Lin YT, et al. *J Am Dent Assoc* 2007[25]
Disruption to quality of life	Low W, *et al. Pediatr Dent* 1999[9] Acs G, *et al. Pediatr Dent* 2001[27] Cunnion DT, *et al. J Dent Child* 2010[28] Filstrup SL, *et al. Pediatr Dent* 2003[29] Sheiham A. *Br Dent J* 2006[42] Casamassimo PS, *et al. J Am Dent Assoc* 2009[47]
Disruption of growth and development (failure to thrive)	Elice CE, *et al. Pediatr Dent* 1990[30] Acs G, *et al. Pediatr Dent* 1992[31] Ayhan H, *et al. J Clin Pediatr Dent* 1996[32] Clarke M, *et al. Pediatr Dent* 2006[37]
Possible disruption of intellectual development	Blumenshine SL, *et al. J Publ Health Dent* 2008[45] Jackson SL, *et al. Am J Public Health.* 2011[46]
Higher incidence of hospitalisation and emergency visits	Fleming P, *et al. Int J Paediatr Dent* 1991[49] Wilson S, *et al. Clin Pediatr* 1997[50] Sheller B, *et al. Pediatr Dent* 1997[51] Oliva MG, *et al. Pediatr Emerg Care* 2008[52]
Increased treatment costs and treatment time	Thikkurissy S, *et al. Am J Emerg Med* 2010[56]
Greater risk of new carious lesions in both primary and permanent dentitions	Johnsen DC, *et al. Pediatr Dent* 1986[57] Grindefjord M, *et al. Caries Res* 1995[58] O'Sullivan DM, *et al. J Public Health Dent* 1996[59] Al-Shalan TA, *et al. Pediatr Dent* 1997[60] Skeie MS, *et al.* Int J Paed Dent 2006[63] Mejare I, *et al. Caries Res* 2001[66]

Introduction

Early childhood caries (ECC) is the presence of one or more cavitated or non-cavitated carious lesions before a child's sixth birthday. Severe early childhood caries (S-ECC) is smooth surface caries in a child less than three years old (**Figure 1**).[1]

Recent reports from several European countries, including Ireland, cast doubt on the effectiveness of treatment of carious primary teeth, with the apparent rationale that they are shed before causing symptoms "in the majority of cases", although when such reports are scrutinised, what constitutes the "majority" is often dubious.[2]

Critical examination of the retrospective, community-based and practice-based studies that form much of the basis for the philosophy of non-restoration or selective restoration of asymptomatic carious primary teeth reveals deficiencies:[3,4]

- data were collected solely from dental records, and so are only as reliable as the information entered on the patients' records;
- no patients were examined or interviewed;
- radiographic examination was rarely performed;
- there is no standardisation of restoration techniques practised, or of materials used;
- there is no comment on restorative techniques practised, or on the quality of restorations placed; and,
- the experience of operators is not addressed.

The quality of restorative work carried out on primary teeth has a bearing on its success or failure. Effective, evidence-based restorative interventions for primary teeth exist; however, inappropriate or poorly performed restorations, where the status of the pulp is not given due consideration, are likely to fail.[5,6,7,8]

The outcome measure of many studies that cast doubt on the effectiveness of treatment of ECC is pain. However, as carious primary teeth can cause serious problems, sometimes with little or no pain, other outcome measures should also be considered.[4,9]

The results of such retrospective studies[3,4] contrast with those of most clinical trials and prospective studies of primary molar restorations.[10]

This paper reviews the evidence regarding consequences of ECC, treatment of carious primary teeth, and outcomes of treatment.

Those who advocate a policy of non-intervention in cases of ECC often express concerns that treatment of young children might result in dental anxiety. This topic is also reviewed.

Consequences of early childhood caries

The Surgeon General of the USA has stated that: "You cannot be healthy without good oral health".[11] ECC has consequences, not only for the teeth of the affected child, but also for the child's general health (**Table 1** and **Figure 2**).

Pain

Shepherd *et al*. interviewed 589 eight-year-old children, and found that almost 50% had suffered dental pain.[12] The pain was of such severity that 73% of those affected had been unable to eat, 31% had been unable to sleep, 27% had stopped playing, and 11% had not been able to attend school.

FIGURE 1: Images of (severe) early childhood caries.
1a: Caries affecting maxillary primary incisors.
1b: Caries affecting maxillary primary incisors and molars.
1c: Caries affecting mandibular primary molars.

Acknowledgement: Thanks to Dr E. Kratunova for permission to use images 1b and 1c.

Early childhood caries (ECC):
- *dmfs* ≥1 in any 1º tooth in a child ≤71 months old.*

Severe early childhood caries (S-ECC):
- *any sign of smooth surface caries in a child <3 y.o.;*
- *dmfs ≥1 (smooth surface cavity) in 1º maxillary anterior teeth at age three to five years;*
- *dmfs ≥4 (age three years);*
- *dmfs ≥5 (age four years); and,*
- *dmfs ≥6 (age five years).*

**d = non-cavitated or cavitated lesion; m = missing due to caries.*

In a retrospective study of dental records of 677 children aged five to 15 years with approximal primary molar caries, Milsom *et al.* stated: "The majority of carious primary teeth exfoliate without causing pain".[13] However, almost half of the children whose records were analysed (48%) had experienced pain, with more than one in four experiencing pain on three or more occasions, and 43% having had extractions due to pain and sepsis.

The authors acknowledged that: "For those children who have decay in their primary molars, dental pain is a common finding".

Levine *et al*. published a more refined retrospective study of 481 case notes of patients with carious primary teeth.[4] In their study, in which standardised chart recording and data extraction methods were used, the same operator had treated all patients. Data were separated into caries affecting single surface, multiple surfaces, and pulp involvement.

Their study revealed that:

- 18% of unrestored carious primary teeth had caused pain;
- pain was significantly more likely the earlier caries presented;
- carious molars were the teeth most likely to cause pain; and,
- teeth with multiple carious surfaces or pulp exposure were more likely to cause pain.

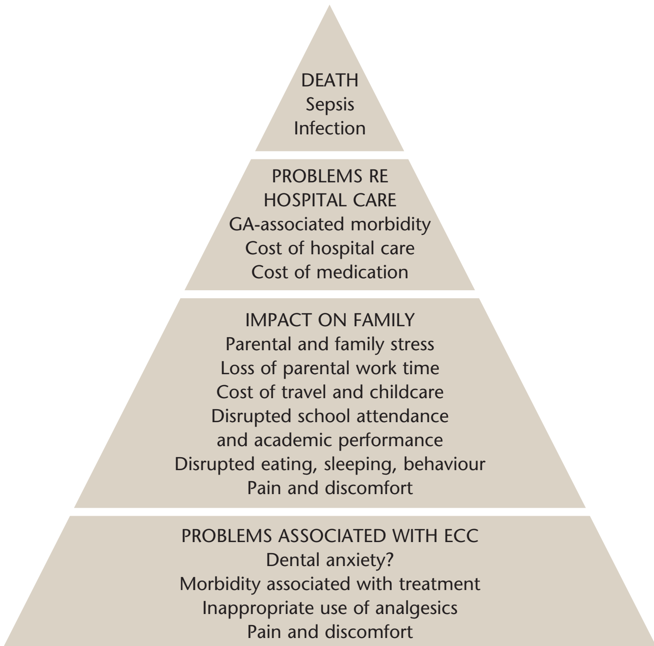

FIGURE 2: Morbidity and mortality pyramid for early childhood caries (Adapted from: Casamassimo, P.S., et al.*).*[47]

FIGURE 3: Examples of facial cellulitis consequent on odontogenic infection. These children were seriously ill and required hospitalisation.
3a: Cellulitis affecting right side upper face. There is a risk of infection of the orbit, and spread to cavernous sinous.
3b: Significant submandibular cellulitis. If untreated, this may progress to Ludwig's angina.
3c: Drainage of submandibular cellulitis, under general anaesthesia (same patient as Figure 3b).
Figures 3b & 3c reproduced from: Cameron, A.C., Widmer, R.P. (eds.). Handbook of Pediatric Dentistry *(2nd ed.). Sydney; Mosby, 2003: 142. The author gratefully acknowledges the permission of Prof. Richard Widmer, Prof. Angus Cameron, and Mosby Elsevier Ltd. to reproduce these images.*

The authors cautioned that while the outcome criteria of their study focused on pain, carious primary teeth can cause painless dento-alveolar infection with potential for serious dental and systemic consequences. They stressed that they were not advocating a policy of not restoring carious primary teeth.

Slade found, in a critical analysis of epidemiological studies of dental pain among children and adolescents, that the prevalence of toothache correlated with caries experience.[14] Correlations were stronger among lower socio-economic groups, consistent with a 5-6% increase in the probability of toothache for each additional carious primary tooth.

Sepsis

A 2006 study by Pine *et al*. in which almost 7,000 Scottish children (mean age 5.3 years) with ECC were examined, revealed that:[15]

- almost 5% of children had dental sepsis;
- those with sepsis had much higher caries experience (mean dmft 6.30) than those without sepsis (mean dmft 2.36);
- the greatest predictor of dental sepsis was untreated decay; and,
- failure to treat carious primary teeth markedly increased the risk of sepsis (**Figure 3**).

The authors concluded that the findings from their study "would not support a policy of non-intervention for deciduous caries if oral sepsis is to be minimised".

A retrospective study by Unkel *et al*. of medical records of patients with facial cellulitis revealed that:[16]

- 47% of facial cellulitis was of odontogenic origin;
- cellulitis was more common in the upper facial region (65% of cases);
- odontogenic cellulitis was more common in the mixed dentition period (mean age 8.8 years); and,
- posterior teeth were responsible for the highest number (64.3%) of odontogenic cellulitis cases.

Dental sepsis can progress to cellulitis, and then to Ludwig's angina, a rapidly progressing cellulitis of the floor of mouth that compromises the airway. One in three cases of Ludwig's angina occur in children and adolescents. The condition is potentially fatal, with a mortality rate of 8-10%, the risk being greater in those with medical co-morbidity. Management requires specialist care, including IV antibiotics, securing of the airway and drainage. General anaesthetic and intensive care facilities are usually required.[17,18]

A recent editorial in *Pediatric Dentistry* reports the deaths of two American children as a result of complications related to odontogenic infections.[19]

Space loss

Premature loss of primary molars may contribute to problems such as deviation of the mid-line, crowding, dental impaction, ectopic eruption and crossbite formation. Longitudinal studies with subjects who have had unilateral premature loss of teeth, using the unaffected side as a control, have revealed that:[20-25]

- following early loss of a primary molar, adjacent molars migrate mesially, while canines drift distally;
- the extent to which migration of adjacent teeth occurs depends on the timing of the tooth loss, the severity of crowding, and the type of tooth that is prematurely lost;
- the reduction in arch length is more severe in the maxilla;
- distal movement of primary canines is greater in the mandible;
- less space is lost following early extraction of primary first molars, compared to primary second molars;
- eruption of permanent maxillary canines can be impaired following premature loss of primary first molars; and,
- premature loss of a second primary molar, prior to eruption of the first permanent molar, results in significant mesial movement of the first permanent molar.

There are, to date, no prospective randomised controlled studies of the consequences of premature loss of primary teeth.

Space maintainers may help to prevent change in arch length following early loss of primary molars; however, evidence supporting their use is limited.[21] The UK National Clinical Guidelines in Paediatric Dentistry recommended space maintenance under the following circumstances:[26]

- following loss of a primary second molar in all but spaced arches; and,
- following loss of a primary first molar, where crowding is greater than half a unit (3.5mm) per quadrant.

The disadvantages of space maintainers are that they are plaque retentive, may impinge on soft tissues, may interfere with eruption of adjacent teeth, and may fracture, become dislodged, or be lost. They require regular review by the dental practitioner. It is preferable, therefore, to retain primary molars, where possible, until their natural exfoliation.[21]

Disruption to quality of life and effects of treatment on ECC

Low *et al*. carried out a questionnaire-based survey to investigate the impact of severe caries on quality of life (QOL) in otherwise healthy young children (mean age 44 months).[9] Parents/guardians of children with severe ECC completed questionnaires pre treatment under general anaesthesia, and four to eight weeks post treatment.

Pre treatment, 48% of the children had complained of pain, 43% had problems eating certain foods (with 61% having reduced intake of food), and 35% had experienced sleep disturbance. A total of 5% had reported problems of negative behaviour. Dental treatment had a statistically significant effect ($p<0.001$) on this cohort of patients, in alleviating the complaint of pain, reversing certain eating problems, and improving sleep habits, while the effect on behaviour was not statistically significant.

Although all children in the sample were affected by S-ECC and required at least one pulpotomy or extraction, only 48% complained of pain. The authors pointed out the difficulty in measuring a young child's degree of pain or discomfort, due to the child's level of cognitive and language development. They noted that pain caused by caries can manifest in various ways: the child may eat less, experience sleep disturbance and/or exhibit negative behaviour. They advised that, as some children do not complain verbally, it is equally important to assess pain by indirect methods, such as through habits or behaviour. The study demonstrated that ECC does affect QOL in children and that, though the children may not complain of pain, they manifest its effects by disrupted eating and sleep habits.

Acs *et al*., who evaluated parents' perceptions of outcomes following their children's complete dental rehabilitation under general anaesthesia, reported similar improvement in QOL.[27] The children in their study were aged 3.5 to 5.5 years, and were categorised upon presence of significant medical or developmentally compromising conditions. Their data revealed that parents perceived improved QOL in their children following comprehensive dental rehabilitation, and that there was a hierarchy of benefits, with the greatest improvement noted in pain experience, followed by improved abilities to eat and sleep. It was noteworthy that the children more likely to have reported improvements in eating, sleeping and overall health, following treatment of ECC, were those who were medically/developmentally compromised.

A recent prospective multi-site study revealed that children with ECC were reported by their parents as having significantly poorer oral health, and worse perceived impact on physical functioning and pain, than caries-free children.[28] Post dental treatment, the children with ECC were rated by their parents as having significant improvement in oral health, and in physical, mental and social functioning, compared to baseline. The authors concluded that children's oral health has a significant impact on their well-being, as assessed by their parents. The positive effects of a dental intervention for the children with ECC were significant at the six- and 12-month follow-ups, and enhanced QOL in multiple domains. The authors developed a new assessment instrument of QOL for this study, in which a large number of parents (n=501) reported on their children.

In a longitudinal intervention study, Filstrup *et al*. investigated the effects of ECC on children's oral health-related QOL before, and four weeks after, its treatment, as assessed by the children themselves, and by their parents/guardians.[29] The study group comprised 69 otherwise healthy children with ECC (mean age 50.4 months), treated by full-mouth dental rehabilitation under GA (one visit), or under LA ± oral sedation (multiple visits). The control group was 43 healthy, age-matched children without caries.

The study revealed that:

- some children as young as 36 months are able to answer questions about their own oral health and oral health-related QOL and, with increasing age, are able to do so reliably and validly;
- children's self-reported oral health-related QOL is significantly correlated with their oral health;
- children with ECC had significantly worse oral health-related QOL than caries-free children, but this significantly improved post treatment; and,
- parents'/guardians' evaluations of their child's oral health-related QOL are significantly related to their child's oral health.

In summary:

- ECC negatively affects a child's QOL;
- children with ECC do not always complain of pain, but can manifest disruption to QOL in other ways, such as eating, sleeping and behaviour problems;
- both parents/guardians and affected children are able to validly report on oral health-related QOL; and,
- treatment of ECC improves the child's QOL.

Disruption of growth and development (failure to thrive), and effects of treatment of ECC

Failure to thrive (FTT) is defined as:

- weight or height below the third percentile for age;
- weight <80% of ideal weight for age;
- failure to maintain a previously established growth pattern; and/or,
- growth failure of unknown origin.

Over the past two decades, several studies have revealed an association between ECC and FTT.

Acs *et al*. reviewed records of 115 children, aged two to four years, with otherwise non-contributory medical history, treated for "nursing caries" using GA or sedation.[31] They found that children with nursing caries weighed significantly less than controls (approximately 1kg less), and were significantly more likely to weigh <80% of their ideal weight. Affected children in the bottom 10th percentile for weight were significantly older than those children at or above their ideal weight, indicating that progression of nursing caries may adversely affect growth.

Similar results were obtained in a study by Ayhan *et al.* in which young children (n=126) with "rampant or nursing caries" were found to be significantly lighter and shorter than controls without caries.[32] The mean weight of children with caries was between the 25th and 50th percentiles, whereas that of children without caries was in the 50th to 75th percentile.

The beneficial effect of dental rehabilitation on the weight and growth velocity of children with ECC was demonstrated in a later study by Acs *et al.*[33] Prior to dental rehabilitation (under GA), children with ECC (aged 2.4-4.8 years at baseline) weighed significantly less than the control group (caries-free children), and were represented by significantly lower percentile weight categories. The authors advised that: "Delay in intervention (dental treatment) appears to have a tangible and adverse impact upon growth".

Post-operatively, the children were reviewed for periods between 10 and 28 months.

Following dental rehabilitation, the children with ECC had significantly increased growth velocities until, after a time, there was no difference in age-adjusted weights between the ECC and control groups, a phenomenon known as catch-up growth.[34,35]

Using body weight alone as a measure of FTT can lead to conflicting results, however, because some of the food choices and eating behaviours that can put an individual at risk of caries are also risk factors for unhealthy weight. Sheller *et al.* illustrated this in a retrospective, cross-sectional case study of 293 otherwise healthy children (aged two to six years) who received treatment under GA for S-ECC.[36] Age and gender-specific body mass index (AGS BMI) and dental status (dmft and number of pulp-involved teeth – determined from operative reports and radiographs) were recorded for each subject. The comparison group (control) was a reference sample from the US Pediatric Nutrition Surveillance System of 2000.

The data revealed that the sample of children with S-ECC did not have a typical weight distribution. The percentage of study subjects in groups "at risk for overweight" and "overweight" was lower than the reference sample, though the difference was not significant.

However, 32% of those with S-ECC had unhealthy weights (being below the 5th or greater than the 85th percentile), of whom a significant number (11%) were underweight. The data revealed that the AGS BMI percentile was not correlated with dmft, or the number of pulp-involved teeth, even after adjusting for confounding factors, though underweight children had the highest mean number of pulp-involved teeth (4.5), though this was not statistically significant.

A more refined study by Clarke *et al*. investigated the nutritional status of 56 children (mean age 3.8 years) with S-ECC, attending hospital for complete oral rehabilitation under GA. Anthropometric measurements (height, weight, mid-arm muscle circumference – indicative of protein stores, triceps skin fold, a measure of fat storage), and blood samples (assessed for serum albumin, haemoglobin, mean corpuscular volume, and serum ferritin) were analysed.[37]

The data revealed that early childhood caries was a risk marker for undernutrition and iron deficiency. All nutrition tests detected malnourishment, with more cases of nutritional deficiency detected by blood tests than by anthropometric measurements. Some 80% of children in the sample were found to have low iron levels. Anthropometric measurements revealed that a significant proportion of children with S-ECC exhibited malnutrition, being below the 90th percentile for ideal body weight (17% of sample), and showing evidence of low fat stores (23%). Despite the evidence of malnutrition from blood tests and anthropometry, tests of body mass index (BMI), using the 5th percentile on childhood charts as a measure for malnutrition, were insensitive and missed many cases.

The findings of Clarke *et al.*[37] that S-ECC is associated with anaemia are significant, as chronic iron deficiency in infancy is associated with impaired brain development and function, and can result in poor school performance. Cognitive scores and behaviour do not improve, even after iron supplementation, if chronic iron deficiency occurs during infancy.[38-41]

Several papers have reported that chronic inflammation (e.g., pulpitis, abscess) affects growth via metabolic pathways. Cytokines (e.g., Il-1) can induce inhibition of erythropoiesis, which leads to anaemia of chronic disease.[42,43,44] Pain due to ECC may also contribute to FTT due to reduced intake of food and disturbed sleep, which affects glucosteroid production and growth.[42]

Disruption of intellectual development

Blumenshine *et al.* carried out a study in which randomly selected parents of 2,871 schoolchildren were interviewed by telephone regarding their child's school performance and oral health status.[45]

The relationship of oral health status and school performance was examined, while accounting for control variables (sex, ethnicity, parental education, school type [public/private], diagnosis of mental health disorder, diagnosis of behavioural health conditions, and diagnosis of learning disability). Parents were 2.3 times more likely to report poor school performance when a child had poor oral health in addition to poor general health. Children with either poor oral health or poor general health were 1.4 times more likely to have a report of poor school performance. The study fell short of implicating oral health as a stand-alone factor in poor school performance.

A recently published follow-up study found that children with poorer oral health status were more likely to experience dental pain, miss school and perform poorly in school. The authors stated that their findings suggest that improving children's oral health status may be a vehicle to enhancing their educational experience.[46]

Hospitalisation and emergency visits

Emergencies related to dental caries in children constitute an important public health problem, with dental pain a common reason for attendance at hospital accident and emergency departments.[47,48]

A retrospective study by Fleming *et al*. at the Royal Belfast Hospital for Sick Children revealed that 4% of after-hours emergency attendances were for dental problems.[49] The ages of the children attending with dental emergencies ranged from one month to 12 years 10 months, with 51% of attendances by children aged five years or younger. Of the 407 dental emergencies (62% male), the most common complaint (49%) was of toothache, with or without abscess. Of the 21% who presented with a dento-alveolar abscess, the majority were related to the primary first molar.

Wilson *et al*. found that of 1,459 children treated in a children's hospital for dental emergencies over a one-year period, 65% presented as a non-traumatic emergency.[50] The patients (52% male) had a mean age of 6.9 years. Dental caries was the aetiological factor prompting 73% of visits, with 33% of patients presenting with a dental abscess.

In a review of emergency dental records over a three-year period, Sheller *et al*. found that 38% of attendances at the Children's Hospital Seattle were for caries-related emergencies.[51] The mean age of the children presenting with a caries-related emergency was 6.4 years, and for 27% of the children the emergency visit was their first contact with a dentist. The most frequent diagnoses were: abscess with sinus tract (44%); caries with spontaneous pain (23%); caries with provoked pain (12%); and, cellulitis (9%). Only 9% of those with caries presented without symptoms. Maxillary first primary molars were implicated in the development of cellulitis in 40% of cases, while maxillary second primary molars were implicated in 17% of cellulitis cases.

Of the 247 emergency hospital visits for non-traumatic dental complaints over a one-year period, Oliva *et al*. found that 59% were by children younger than five years, 53% presented in pain, and 8% had severe infections requiring hospitalisation for intravenous antibiotics.[52]

Pain due to ECC can lead to medical problems due to inappropriate use of over-the-counter medications, which may ultimately result in the need for emergency hospital admission. Paracetamol is frequently used for management of ECC-related pain in children. Hepatotoxicity due to excessive administration of the drug by parents for management of their child's odontogenic pain is a growing concern in paediatric emergency medical care.[47,53]

Treatment time and costs

In terms of cost to the community, care of ECC consumes a significant amount of healthcare budgets, due to the extent of the problem and the frequent need for use of emergency and general anaesthetic facilities.[47]

A recent paper by Davis *et al*. investigated the costs involved in patients receiving emergency outpatient hospital treatment (not including extractions or restorations) for dental problems, in Minneapolis-St. Paul, USA.[54] They found that over a one-year period there were over 10,000 visits to hospital emergency rooms (ER) for dental-related problems, 2% by children aged less than five years, at an average cost of $459 per patient. Nearly 25% of the visits were second, or more, visits to the same ER for care of a dental problem, indicating that while ER physicians treated acute pain and infection, the underlying dental problem was often not resolved. Gift *et al.* estimated 164 million hours of lost work time and 51 million hours of lost school time as a result of dental problems in the USA in 1989.[55]

A recent retrospective study from America of medical records of children admitted for treatment of odontogenic cellulitis revealed that the mean length of stay in hospital was 2.08 days, while the mean cost of hospitalisation was $4,166.[56]

Greater risk of new carious lesions in both primary and permanent dentitions

Many studies have demonstrated an association between caries in pre-school children and further caries development (incipient lesions becoming cavitated and/or development of new carious lesions).[57-60]

In a longitudinal study (n=692 children, aged 2.5 years at baseline), Grindefjord *et al*. demonstrated that 92% of children diagnosed with caries at baseline developed new carious lesions over a one-year period.[58] Of the children who were caries-free at baseline, 29% developed caries during the study period. The difference was significant ($p<0.001$). The majority of new lesions were located on the occlusal surfaces of second primary molars. Some 64% of the lesions diagnosed at baseline as initial caries progressed to manifest lesions during the study period. The children with caries at baseline developed significantly more proximal lesions in molars than those who were caries free at baseline. Some 56% of the children in this study were of immigrant background.

The study indicated that children manifesting caries early in life exhibit high caries progression, as well as high risk for development of further new lesions.

It is well established that past caries experience in a child is the strongest single predictor of future caries.[61-64] However, a recent prospective study by Fontana *et al*. in which 329 pre-school children (26±6 months old at baseline) were examined, and subsequently re-examined one year later, revealed the risk factors for caries progression towards cavitation to be: family caries experience; transmission-related behaviours; dietary factors; health beliefs; and, lower income.[65] Addition of clinical variables (baseline caries experience, dental plaque, gingivitis, mutans streptococci counts, proportion of mutans streptococci/total streptococci) did not improve the predictive power in this cohort of very young children.

In a prospective longitudinal study of 186 children, examined at ages five and 10 years, Skeie *et al*. found significant correlations between the caries experience in the primary and permanent dentitions, and between the primary second molars at baseline and the permanent teeth at 10 years old.[63] The authors suggested that a clinically useful predictor, at five years of age, for being at high caries risk at 10 was primary second molars with more than two surfaces exhibiting caries.

A retrospective study assessing annual bitewing radiographs of

Table 2: Benefits accruing from treatment of early childhood caries.

Benefit	References
Carious teeth are restored to function	Stephenson J, *et al. Caries Res* 2010[10]
Pain and discomfort are resolved or prevented	Low W, *et al. Pediatr Dent* 1999[9] Acs G, *et al. Pediatr Dent* 2001[27]
Risk of sepsis is reduced	Pine CM, *et al. Br Dent J* 2006[15]
Space loss is lessened or avoided	Laing E, *et al. Int J Paediatr Dent* 2009[21]
The child's oral health-related quality of life improves	Low W, *et al. Pediatr Dent* 1999[9] Acs G, *et al. Pediatr Dent* 2001[27] Cunnion DT, *et al. J Dent Child* 2010[28]
Beneficial effects on child's growth and development	Acs G, *et al. Pediatr Dent* 1999[33]
Child's educational experience may be enhanced	Blumenshine SL, *et al. J Publ Health Dent* 2008[45] Jackson SL, *et al. Am J Public Health.* 2011[46]

children (n=374) was conducted by Mejare *et al*. to investigate the influence of the caries status of the second primary molar's distal surface on the caries rate of the mesial surface of the proximal first permanent molar, from six to 12 years of age.[66] The study revealed that the caries rate for the first permanent molar depended on the status of the distal surface of the proximal second primary molar. The caries rate for the mesial surface of the first permanent molar increased 15 times if the distal surface of the proximal second primary molar had enamel/enamel-dentin caries, compared to a sound distal surface of the second primary molar.

In a four-year prospective study (assessing annual bitewing radiographs of 196 children aged six to eight years at baseline), Vanderas *et al*. found that the presence of distal caries in second primary molars increases the risk of developing mesial surface caries in the proximal first permanent molars.[67] They also observed that the greater the period of exposure of the first permanent molar's sound mesial surface to the carious lesion of the second primary molar, the greater is the risk of developing caries on the sound surface. The risk of developing mesial surface caries in first permanent molars was found to be different among the studied paired surfaces, indicating different cariogenic conditions at each proximal surface. The authors concluded that caries developing on the mesial surface of mandibular first permanent molars is primarily due to distal caries in second primary molars, whereas in the maxillary teeth, other factors, together with distal caries in the second primary molars, should be considered. They found that if the distal surfaces of the second primary molars are sound, the risk of developing mesial surface caries in first permanent molars is low.

Benefits accruing from treatment of ECC

A recent cohort study of data from more than 5,000 carious molars of 2,654 British children aged four to five years at baseline, augmented with Dental Practice Board treatment data, assessed the effect of restorative treatment on the likelihood of carious teeth subsequently progressing to exfoliation or extraction (**Table 2**).[10]

The study revealed that beyond four years of age, filling carious primary teeth substantially improves the likelihood of a "successful" outcome (subsequent natural exfoliation without the need for extraction). It was found that more than 80% of all carious teeth that were filled subsequently exfoliated naturally.

The time of occurrence of caries was seen to affect survival experience, with higher survival rates of teeth in which caries occurred later in life. When primary molars were filled, it was observed that later occurrence of fillings was also associated with higher survival rates.

Studies demonstrating the beneficial effects of treatment of ECC on the child's quality of life, and growth and development, have been discussed previously.[9,27,28,29,33]

Is treatment of early childhood caries associated with dental anxiety?

The prevalence of dental fear in children is reported as 5-20% (mean 11%).[68,69] Newton described a simple model to explain the development of dental anxiety:[70]

Direct conditioning is a process whereby the experience of traumatic events or treatments is associated with development of fear – the child learns to associate pain and distress with the dental setting. However, if the child has positive dental experiences, he/she will learn to have a positive attitude towards dental treatment.

Latent inhibition is a process whereby if positive dental experiences are followed by a traumatic event, prior learning inhibits the child's development of dental fear.

Dental anxiety disorders are, however, of multifactorial and complex origin.[71] Many people with no dental fear have had negative dental experiences, while some with considerable dental fear fail to recall any traumatic incidents. A study by Davey revealed that subjects who reported never having had anxieties about dental treatment were less likely to have had a painful dental treatment than those who did report an anxiety.[72] Those who did report a painful dental experience, but did not acquire anxiety, reported a history of dental treatment favourable to the operation of latent inhibition. Under some conditions in which latent inhibition should have precluded the acquisition of a dental fear, anxiety appeared to be acquired because a very painful experience had attenuated the latent inhibition process. The author concluded that: "Those subjects whose dental anxiety did not remit reported significantly more painful and traumatic dental experiences than those whose anxiety did remit."

A questionnaire-based survey by Armfield of more than 1,000 adults chosen at random, revealed that negative dental experiences were significantly associated with dental fear.[73] However, cognitive perceptions of uncontrollability, unpredictability, danger and disgust were superior predictors of dental fear, compared with negative dental experiences. This, according to the author, supports the cognitive vulnerability model, which proposes that a person's perception of a stimulus or situation is the important factor in determining anxiety or fear, rather than any particular experiences that he/she may have had.[74]

A longitudinal study by Raadal *et al*. investigated the relationship between caries prevalence at five years, and dental anxiety at 10 years of age.[71] Dental anxiety was measured at age 10 years by means of a psychometric questionnaire, which parents completed by interviewing their children.

At five years of age, the majority (68%) of children who subsequently exhibited high dental anxiety at 10 had mean dmfs of 10.7, while those with low anxiety had significantly lower dmfs (mean 4.7).

The authors concluded that children with many carious lesions at five years of age are at high risk of being dentally anxious at 10. They proposed that the most likely reason is classical conditioning (including procedural pain and other negative experiences during dental treatment, as the unconditioned stimuli), but they offered no proof of this. The authors stated that the children surveyed had received treatment of their carious teeth between ages five and 10, and thus concluded that: "The study supports the assumption that treatment of caries in early childhood represents a risk for acquisition of dental anxiety". Robust proof to support their conclusion, however, was not demonstrated. They cautioned that high caries levels at age five do not necessarily lead to dental anxiety, as nearly 75% of five-year-olds with dmfs of 6 or greater did not report high dental anxiety at age 10, demonstrating that dental anxiety is of multifactorial origin. They also advised that, as anxiety at five years of age was not measured, the findings at 10 years of age are not a follow-up of dental anxiety during this period.

In a cross-sectional, questionnaire-based study of five-year-old children, in which parents reported regarding their own and their child's anxiety, 10.8% judged their child to be dentally anxious.[75] The children's dental anxiety was associated with symptoms, irregular attendance pattern, a history of dental extraction, and having a dentally anxious parent. Dentally anxious children had significantly higher caries experience than those who were judged not to be anxious (dmft 2.58 vs. dmft 1.12). A history of restoration of teeth was not found to be a significant predictor of anxiety in this cohort of children. The cause and effect dynamics of these relationships were not determined. The authors noted that children who are sporadic attenders often present in pain, when extraction may be the only possible treatment option. Such a pattern of attendance and treatment may perpetuate dental anxiety.

Locker *et al*. carried out a questionnaire-based cross-sectional study in which more than 3,000 randomly selected adults participated.76 Data were obtained regarding negative dental experiences and their relationship to dental anxiety. Three-quarters of those surveyed reported direct negative experiences, of which 71% were painful, 23% frightening and 9% embarrassing. Only 37% of the negative experiences occurred during childhood, with 23% occurring during adolescence and 40% in adulthood. The relationship between negative experiences and dental anxiety was found to be strong. Those who experienced all three negative experiences (pain, fright, embarrassment) were at 22.4 times greater risk of dental anxiety than those with no negative experience. The data suggested that while painful experiences were predictive of dental anxiety, other types of experience, alone or in combination with pain, showed a stronger relationship. The nature of the unpleasant experiences was found to be more important than the age at which they occurred, in predicting dental anxiety.

The authors advised that the study results should be interpreted with caution as, though they were consistent with a causal role, there could be no certainty that the reported negative events preceded the onset of anxiety. They advised that the causal direction might be opposite; that is, anxious subjects might be more likely to characterise previous dental experiences as negative, even if they did not play an aetiological role in their anxiety.

A later study by Locker *et al*. aimed to identify the age of onset of dental anxiety, and to identify differences by age of onset with respect to aetiological factors, such as negative dental experiences, family history of dental anxiety, and general psychological states.[77]

1,420 subjects responded to mailed questionnaires, which revealed that 16.4% were dentally anxious. Half the study population reported onset of dental anxiety in childhood, one-fifth in adolescence, and almost one-third in adulthood. Logistic regression analysis indicated that negative dental experiences were predictive of dental fear regardless of age of onset, while a family history of dental anxiety was predictive of childhood onset only. Subjects whose onset of dental anxiety was in adolescence were characterised by trait anxiety, while those with onset in adulthood were characterised by multiple severe fears and symptoms indicative of psychiatric problems. The authors concluded that subjects with onset of dental anxiety in childhood were more likely to fall into the exogenous aetiological category, while those with adult-onset anxiety were more likely to fall into the endogenous category.

According to Milgrom *et al*. the consequences of traumatic dental experiences are dependent on the context in which they occur.[78] This means that pain inflicted by a dentist is likely to have less psychological impact if the dentist is perceived as caring, rather than one who is cold and controlling. This highlights the importance of good, appropriate communication and behaviour management techniques, which enhance the child's trust and feelings of control.

A recent study, in which 1,303 children aged five to 12 years were examined and interviewed in school, revealed that those who had previous restorative dental care were significantly less anxious than those who had no previous dental care.[79] This indicates that early dental intervention, if properly managed and not stressful, can have a positive impact on dental fear.

It is not the purpose of this paper to describe behaviour management techniques for dental care of children. The reader is referred to relevant articles and texts.[80-83]

In a recent meta-analysis of the relationship between parental and child dental fear, the majority of the 43 international experimental studies included confirmed a link between parental and child dental fear, which was most evident in children aged eight years or younger. The studies varied widely, however, in terms of research design, methods, age of children, and reported link between parental and child dental fear.[69]

Although a small number of studies have established associations between negative dental experiences and dental fear[72,75,76,77] these, according to Armfield *et al.*, are the exception rather than the rule.[73] This does not, of course, negate the possible influence of aversive experiences in the aetiology of dental fear.

If difficult procedures are more likely to lead to dental anxiety, then dental intervention and, where necessary, treatment should ideally occur early, before problems escalate. Early intervention would result in easier, less traumatic treatment than that required for a symptomatic tooth.

Several authors have highlighted the likely benefit of early, non-emergency intervention in terms of prevention of onset of dental fear and anxiety in children.[79,84]

Paediatric dental societies, and some State agencies, have adopted policies encouraging the early introduction of children to dental healthcare and prevention, in an attempt to prevent caries.[85-87] In addition to likely benefits in reducing onset of anxiety, early intervention to prevent and treat ECC has been modelled as both cost effective and cost saving.[47,88,89]

In summary, although it is often stated that treatment of ECC may contribute to dental anxiety, this is not invariably true. Traumatic early dental experiences seem more likely than non-traumatic ones to result in anxiety; however, the causes of dental anxiety are multifactorial.

Conclusions

This review has demonstrated that ECC has implications for both the dental and general health of the affected child. Such problems are potentially serious, even life-threatening. Evidence has been provided of the beneficial effects on dental and general health of dental rehabilitation of children with caries.

Causes of dental anxiety are multifactorial, and treatment of ECC does not invariably contribute to dental anxiety, as long as the child's experience of dentistry is not traumatic.

Children with the highest levels of dental disease are primarily from disadvantaged communities. Failure to adequately treat their dental disease may further disadvantage these children.[31,32,37,47,90]

Paediatric dental societies, renowned experts in paediatric dentistry, and the Medical Protection Society (Dental Protection) do not support a policy of leaving carious primary teeth untreated.[2,91,92,93,94]

Finally, a quote from Professor Aubrey Sheiham is particularly pertinent: "Treating caries in pre-school children would increase growth rates and the quality of life of millions of children. Prevention of caries would be preferable to treatment, but the high level of untreated caries worldwide suggests that current preventive approaches are not working".[42]

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