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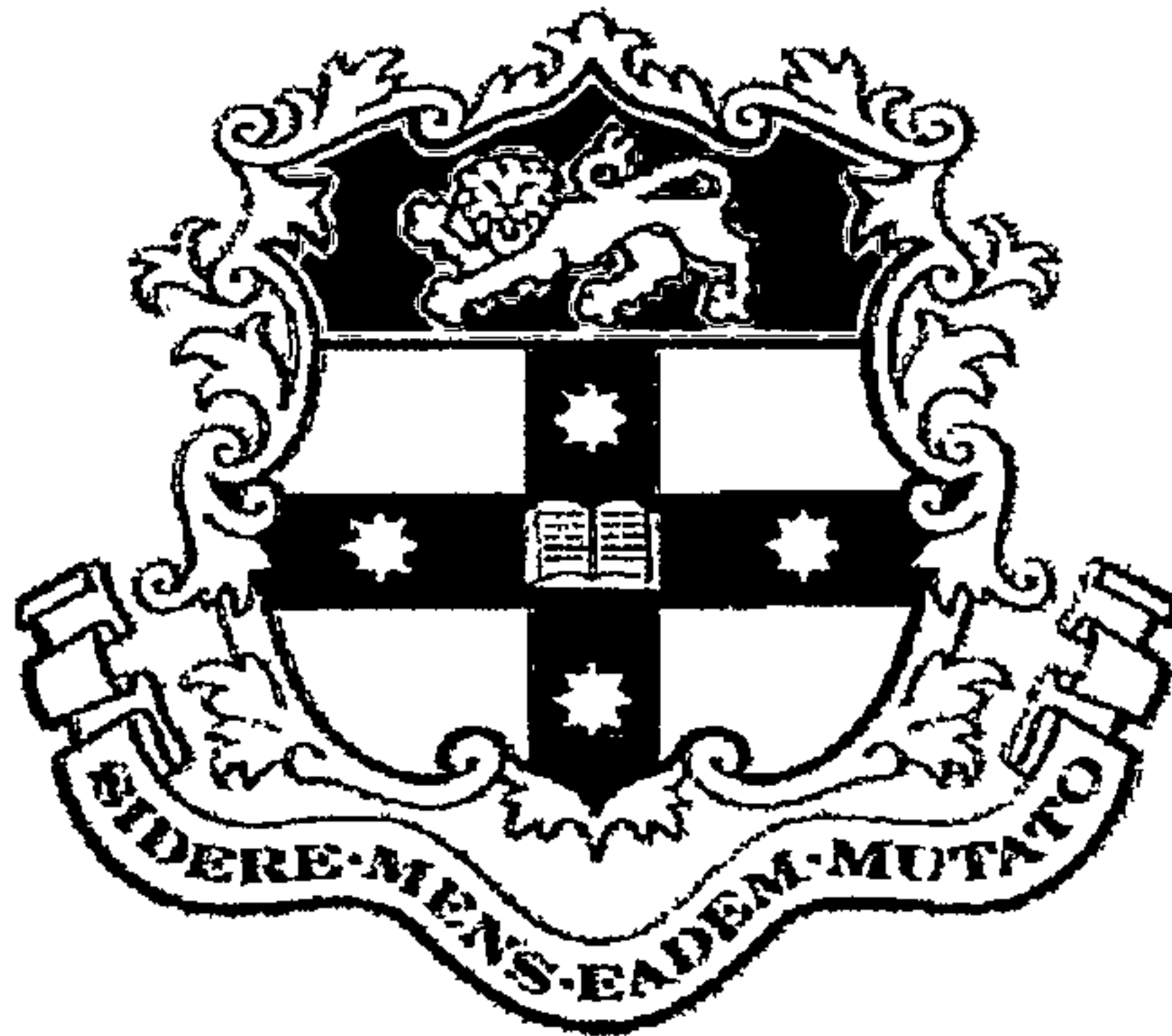
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# **The Demand for Dental General Anaesthesia in Children at Westmead Hospital, Sydney, Australia**

**Eduardo A. Alcaino**  
**BDS (Hons), FRACDS**

A Thesis submitted in partial fulfillment of  
the requirements for the degree of Master  
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Discipline of Paediatric Dentistry  
Faculty of Dentistry  
University of Sydney  
Australia

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## ABSTRACT

### **The demand for dental general anaesthesia in children at Westmead Hospital, Sydney, Australia.**

The use of general anaesthesia (GA) to provide dental treatment for children has been reported for several decades. The aim of this study was to assess demographic factors and nature of treatment provided for children treated under GA at Westmead Hospital. Randomized samples of patients from 1984 and 1996 were selected and data collated in a retrospective manner; information such as age, suburb of residence, waiting list time, reason and source of referral, ethnicity and treatment provided were recorded. The data was analysed using T-tests and Chi-square tests. Results showed that certain populations of Sydney provide greater number of children requiring GA services. There was a steady increase in the demand for this service, from a total of 212 children in 1984 to 777 in 1996. Dental caries was the main reason for referral, with an increase from 70% in 1984 to 83% in 1996 ( $p < 0.05$ ), with over two thirds of the children being under 6 years of age. The ethnicity of these children has changed over the 12-year period, with more Asian and Middle Eastern children being treated in 1996. Self referred/emergency patients, general practitioner dentists, and The School Dental Service were the main sources of referrals. The nature of treatment has changed significantly with 20% more primary teeth being extracted in 1996 than in 1984. The mean waiting time increased from 37 to 80 days in the 12-year period, indicating that the demand has outstripped its provision. The increase in demand for GA services may be attributed to: changes in pattern of caries distribution, changes in demographics, increased restrictions for GA services in the private sector, and changes in the public dental services. Despite a general decline in caries in Australia, nursing and rampant decay still remain a significant problem in certain communities within Sydney. The demand for dental treatment under general anaesthesia has increased over the past two decades with caries remaining the main reason for use of this service.

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# Chapter 1 . LITERATURE REVIEW

## Introduction

The main topic of discussion of this literature review is the use of general anaesthesia (GA) in paediatric dentistry. The use of this technique in paediatric dentistry is one of many when dealing with the very young, the medically compromised or any child unable to receive treatment in a more conventional way. The use of general anaesthesia however has remained controversial over the years as many clinicians have felt that dental treatment does not justify the use of GA due to its inherent risks. Nonetheless, this technique has been used routinely and successfully for several decades.

Before addressing the history, development, safety and current use of GA in children, this literature review will address briefly the question of why general anaesthesia is needed in paediatric dentistry. It will do this by reviewing the aetiology and factors that influence behaviour and fear, and then review current knowledge and the efficacy of alternative methods of managing children.

The second section of this review deals with several aspects of general anaesthesia. The history and development of anaesthesia help us understand how GA has evolved over time. It also highlights the origins of day-stay surgery and how it developed in dentistry. Safety of GA is included, as mortality and morbidity are the major objections to its use in dentistry. A brief description of the drugs and monitoring devices currently used in general anaesthesia has been included to highlight the most commonly used drugs and techniques available. In addition, this section discusses special considerations that apply to children undergoing GA such as anatomical, physiological and psychological differences as compared to adults. A

brief discussion of the current guidelines and regulations that dictate how GA is practiced in NSW is also addressed.

The third section reviews the literature on the use of GA in paediatric dentistry. As the characteristics of these studies varies considerably, a summary of the most relevant information is given in order to compare and analyse the findings of this study with others around the world.

The last section describes the delivery of paediatric dental services in NSW. A description of the oral health of children in Australia is given. Who provides dental care to children in the state of NSW is briefly discussed. Westmead Hospital is the main provider of paediatric dental GA services in the state and the location of this study. A description of the Paediatric Dentistry Unit and the day-stay GA unit is therefore given. This allows a better understanding of the delivery of services at Westmead Hospital, an insight into the structure and functioning of the GA unit, and an appreciation of the demand for paediatric dental general anaesthesia at this hospital.

## Management of the paediatric patient

The genesis of Paediatric Dentistry is due to the dental and orofacial problems that affect children. Undoubtedly, the most common problems are related to dental caries, pulpitis, and the inflammation and pain associated with infected pulpal tissue and suppuration in alveolar bone (Pinkham, 1994).

Paediatric Dentistry, as a body of knowledge and as a clinical discipline, has borrowed heavily from other specialty areas in dentistry. In addition to this knowledge, a clinician that handles children must know certain basics in paediatric medicine, general and oral pathology, and growth and development. Knowledge of nutrition and an understanding of both systemic and topical fluorides are also essential in the development of appropriate prevention strategies for the child patient (Pinkham, 1994).

The successful management of children requires an understanding of their emotional and psychological needs as well as their processes of emotional change and social maturation. The child has to be managed differently than the adult and, in fact, the modes of management are extremely age related (Pinkham, 1994). Without doubt, the effective and sympathetic management of pain and the associated anxiety is central to the practice of paediatric dentistry. A major difficulty for paediatric dentists is the varied responses of children of widely different ages to painful stimuli (Roberts, 1997). Infants up to about 2 years of age are unable to distinguish between pressure and pain. After the age of approximately 2 and up to the age of 10, children begin to have some understanding of "hurt" and begin to distinguish it from pressure or "a heavy push". The problem is that it is difficult to identify those children who are amenable to explanation and respond by being cooperative when challenged with local anaesthesia and dental treatment (Roberts, 1997). Children over the age of 10 are much more likely to be able to think abstractly and participate more actively in the decision to use local anaesthesia, sedation, or general

anaesthesia. Indeed as children enter their teenage years they are rapidly becoming more like adults, and are able to determine more directly whether or not a particular method of pain control will be used (Roberts, 1997).

### ***Behaviour and Dentistry***

The behaviour of children in the dental environment is one of the most difficult aspects when treating young patients. Anxious children demand considerable time, effort, and clinical expertise from the operator. While the vast majority of young children can readily accept dental care, there are many for whom dentistry can be difficult. The majority of young children have very little idea of what dental treatment involves and this will raise anxiety levels. Most children will cope if given friendly reassurance from the dentist, but some patients will need a more structured programme (Roberts, 1997). This section will address the behaviour of children in the dental clinic and how dentists behave and respond to the different demands imposed by children. The behaviour of parents towards dentistry is discussed, and how this influence may alter the interaction between dentist and child.

### **Perceptions and Behaviour of Children**

Fear of dentistry is a common problem for patients and dentists. Very often this fear of dentistry stems from a bad experience in childhood. Fear is also rated as the principal management problem encountered by dentists and is implicated as an important factor in broken or cancelled appointments (Murray and Niven, 1992).

Fear of dental treatment, resulting from painful experiences and learning from others, has been shown to be a major factor in children not seeking dental care in both Finland and the United States (Alvesalo et al. 1993; Murtomaa et al. 1996). Such fear is particularly associated with injections and drilling when treating children. Poor dental experience in

childhood may also be associated with lower rates of utilisation among adults (Alvesalo et al. 1993). For these reasons, it is important to ensure that the dental experiences of children are as painless as possible. A scared child confronted by a dentist can be either fearful or anxious. The child may fear something specific such as an injection, or may be anxious about what the dentist intends to do, without any knowledge of the planned procedure. The level of fear can vary from mild apprehension, which can be overcome by a calm and reassuring approach, to abject terror, which prevents any dental work from being carried out without recourse to a general anaesthetic (Murray and Niven, 1992).

Sedation and general anaesthesia are indicated when treating uncooperative or unmanageable children, rather than subjecting them to stressful visits. It has been shown that children become increasingly sensitised to repeated stressful procedures, and this is accompanied with decreased cooperative behaviour (Venham and Quatrocelli, 1977). The behavioural changes of children undergoing dental treatment using oral sedation versus general anaesthesia have been described previously (Camm et al. 1987). It was noted that children who received dental treatment with oral sedation underwent behavioural changes similar to those children who received dental treatment with general anaesthesia. According to their mothers, both groups exhibited postoperative behavioural changes (within a 7-day post-operative period) not seen by children receiving routine dental treatment (Camm et al. 1987).

### Perceptions and Behaviour of Dentists

It is evident that dentist behaviour can affect a child's perception of dentistry and that this perception is variable in the genesis of dental anxiety. There have been some studies that have concentrated on the interface between child and dentist behaviour within the dental surgery (Alwin et al. 1994; Weinstein et al. 1982).

It has been suggested that the response of a dentist to a child's fear related behaviour is based more on the dentist's own personality than on established management techniques. The highest probability of reducing fear related behaviour are methods such as giving direction, reinforcement, and questioning for feeling (Weinstein et al. 1982). A similar study from the U.K. found that dentists changed their behaviour when dealing with anxious children (Alwin et al. 1994). Dentists adopted some, but not all, of the anxiety management techniques that have been found in previous studies to reduce stress of dentally anxious children.

The perception of pain experienced by children is often uncertain. Health professionals who control whether or not child patients receive medication or anaesthesia are responsible for estimating the level of pain felt by these children. Health professionals often hold misconceptions about children's pain and tend to underestimate it clinically. A recent survey of Finnish and American dentists found more similarities than differences between these two groups of dentists. Both groups rated the pain associated with dental treatment at about the same level, but they seemed to underestimate the pain and unpleasantness of dental treatment (Murtomaa et al. 1996). This finding has also been reported previously (Milgrom et al. 1994). Interestingly, there was little relationship between perceptions and management of pain. Dentists who rated treatment as more unpleasant were more likely to question children about pain. On the other hand, the dentist's perception of a child's pain appeared unrelated to the use of anaesthetics, which presumably may result in many dentists providing inadequate pain control (Murtomaa et al. 1996). Alwin and coworkers reported the incidents that parents think might have contributed to dental fear. Parents of anxious children were able to cite a specific incident in 75% of cases. The most common incident was dentist manner, followed by general anaesthetic, fear of needles, extractions, and 'drilling and filling' (Alwin et al. 1991).

There appear to be substantial differences between the way dentists and patients perceive pain and pain management, and how ethnic backgrounds affect pain description. This may affect how patients are treated and, thus, their future likelihood of seeking dental care (Murtomaa et al. 1996; Moore et al. 1986). A study assessing cultural perceptions of pain indicated that ethnicity may play a stronger role in the perceptions of pain description than does professional socialisation. This last term is defined as the process whereby standards for what exists, what goals are to be valued, and how one should behave are learned by a mutually identified group of individuals within an occupation (Moore et al. 1986).

Although all dentists use child management techniques, paediatric dentists receive additional training and experience. Factors such as sedation guidelines, informed consent requirements, variation in state dental practice acts and professional liability insurance may affect the use of management procedures (McKnight Hanes et al. 1993). Surveys from American studies show that paediatric dentists employ a broader spectrum of management techniques as compared to general dentists; also, there are variations in dentist's age and area of practice (McKnight Hanes et al. 1994; McKnight Hanes et al. 1993). Furthermore, paediatric dentists perceive that they treat younger patients, more handicapped patients, more behaviour problems, and more children that require general anaesthesia than general dentists do.

## Parental Attitudes

Parental attitudes in general, and towards dentistry in particular, have a profound influence on a child's behaviour. Factors thought to be important include the age of the parents and their level of maturity. Positive dental attitudes in parents will create an environment for the child that is compatible to the acceptance of good dentistry (Malamed, 1995j). The parent's prior experience with medical and dental health professionals will greatly influence their child attitudes. Although few parents would tell their children of prior traumatic experiences they have had, such attitudes and feelings may be transferred to the child via nonverbal

communication (Malamed, 1995j). There is no general consensus among dentists whether a parent should be permitted in the surgery, but trends reveal increased parental presence and involvement in decision-making and provision of care (Nathan, 1989).

The presence of parents in the surgery should be agreed upon mutually, with the child's best interests in mind. The need to spend time to eliminate the parent's fears and provide counselling with respect to the parent's role and expectations are essential to the overall management plan for child and parent alike (Nathan, 1989). Parental attitudes must be taken into account when considering the use of sedation; however, the clinician must always make the final decision. There is evidence that parents, especially mothers, suffer more stress and anxiety while their children are treated under sedation or GA than mothers whose children received routine dental care (Camm et al. 1987).

### ***Management of pain and anxiety in children***

The different methods of pain control in dentistry for children vary from simple behaviour management to full intubation general anaesthesia in a hospital operating theatre. In general terms, there are two main methods by which children are treated in dentistry: pharmacological and non-pharmacological. Non-pharmacological methods refer to techniques that deal with behaviour management and hypnosis (Shaw and Niven, 1996b; Gokli et al. 1994), whereas pharmacological methods could be subdivided into:

1. Local Anaesthesia
2. Relative Analgesia (Inhalational sedation)
3. Other forms of Sedation
4. General Anaesthesia

## Behaviour Management of Children

Considerable efforts have been directed toward the development and assessment of various strategies to manage the difficult manifestations of dental fear and anxiety in children. Nonetheless, it is equally important to the dental profession to investigate how to prevent or intercept dental fear at the outset. Fearful children demand considerable time, dedication, and expertise from the dental team. Therefore, it is imperative that dental experiences be favourable if the profession is to help the public maintain oral health, and seek periodic preventive as well as restorative care (Weinstein and Nathan, 1988). Although childhood fear is normal and healthy, fears may persist and produce profound disabilities. Dental fear, whether learned as a consequence of aversive child management practices or through negative expectations from others, may set the stage for traumatic dental experiences and/or subsequent avoidance of needed dental treatment. The long-term consequences may influence health, appearance and general welfare (Weinstein and Nathan, 1988).

There is a strong correlation between the perception of pain experienced and the degree of anxiety perceived by the patient. Painful procedures cause fear and anxiety; fear and anxiety intensify pain. This circle of cause and effect is central to the management of all patients. Good behaviour management reduces anxiety, which in turn reduces the perceived intensity of pain, which further reduces the experience of anxiety (Roberts, 1997). Dentistry should be seen as a stressful experience that mobilises the child's existing coping abilities. The outcome of this experience is determined not only by the child's particular expression of fear and coping, but also by the clinician's choice of appropriate management strategies and his/her desire to successfully treat the child and not just the dental problem. It is important to note that the use of some management strategies may result in temporary cooperation at the cost of intensifying fears or phobias. On the other hand, successful management of dental fear may not only result in better future dental outcomes, but may enhance the ability of the child to cope with other fearsome situations (Weinstein and Nathan, 1988).

One of the objectives of using management control techniques is to achieve positive behaviour not only short term but also to create a positive dental attitude as the child gets older. A Swedish study investigated 146 children with dental fear, aged 3 to 13 years, regarding how they accepted dental treatment after five years. Caries incidence was high in 71% of the patients. Conventional treatment was given in 48%, 25% needed conscious sedation, and 27%, were treated under general anaesthesia. After five years, 78% of the children showed good acceptance of conventional dental treatment while 18% received conscious sedation and 4% general anaesthesia. Good cooperation was seen significantly more often in children referred at the age of 3- 8 years than when referred at an older age. Good acceptance was also found significantly more often when conventional treatment had been given (Varpio and Wellfelt, 1991).

Familiarisation of the patient to the dental environment and the allowance of enough time for the child to feel comfortable, are important steps familiar to the paediatric dentist. Recognised behavioural methods for reducing fear and pain sensitivity are summarised in Table 1.1 (Cameron and Widmer, 1997).

|                                   |                                                                                                                                                           |
|-----------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Tell-Show-Do</b>               | Informing, then demonstrating, and finally performing part of a procedure.                                                                                |
| <b>Playful Humour</b>             | Using fun labels and suggesting use of imagination.                                                                                                       |
| <b>Distraction</b>                | Ignoring and then directing attention away from a behaviour, thought, or feeling to something else.                                                       |
| <b>Positive Reinforcement</b>     | Tangible or social reward in response to a desired behaviour.                                                                                             |
| <b>Modeling</b>                   | Providing an example or demonstration about how to do.                                                                                                    |
| <b>Shaping</b>                    | Successive approximations to a desired behaviour.                                                                                                         |
| <b>Fading</b>                     | Providing external means to promote positive behaviour and then gradually removing the external control.                                                  |
| <b>Systematic Desensitisation</b> | Reducing anxiety by first presenting an object or situation that evokes little fear, then progressively introducing stimuli that are more fear provoking. |

**Table 1.1:** Behavioural methods for reducing anxiety in children

The use of aversive techniques such as physical restraint devices and hand-over-mouth technique is controversial. A survey of American paediatric dentists found that the need for some form of physical restraint was low (4%). There was a tendency to limit the application of restraining devices (pedi-wrap, papoose board) to either handicapped or sedated patients for the purpose of preventing potentially harmful reflex movements (Nathan, 1989). The use of the Hand-over-mouth technique (Levitas, 1974; Craig, 1971) has become controversial on the basis of perceived harshness, lack of informed consent and possible issues of assault. In recent years, paediatric dentists and other health professionals have developed a greater interest in the issue of informed consent largely due to an increase in malpractice litigation and ever-escalating cost of liability insurance. The use of control techniques that carry the potential for misuse (hard restraints, hand-over-mouth, sedation and general anaesthesia) require the practitioner to obtain the informed consent from the legal guardian, and also to be able to produce written evidence of this consent (Nathan, 1989; Klein, 1991; St.Clair, 1995).

Wright and coworkers investigated particular behavioural and pharmacological techniques used by a sample of Australian dentists (219 general dentists and 48 members of the Australian Society of Dentistry for Children) to deal with children's anxiety and behaviour. The management strategies and their frequency of use, derived from answers to a questionnaire were as follows: allow child to raise a hand or similar to stop treatment (79%); furnish toys in the waiting area (72%); use of behavioural methods such as positive reinforcement and coaxing (68%); use of Tell-Show-Do (60%); let child hold toys and mirror during treatment (52%); and offer child reward after appointment (51%). In contrast, the most frequent unpopular strategies were: the use of TV or tapes during treatment (86%); film or video modeling (85%); hypnosis (83%); and Hand-over-mouth technique (74%) (Wright et al. 1991b). The authors concluded that 'paediatric dentists' would more frequently perform all forms of management strategies than general dentists, and that younger dentists would be more likely to use behavioural management techniques than older dentists. When comparing Australian with North American and British strategies, the

authors noted similarities between Australian and British dentists. North American dentists tended to use hand-over-mouth as a common strategy, whereas Australian and British dentists had a higher rate of using general anaesthesia. Rather surprisingly the use of relative analgesia, hardly featured at all in this study and was relegated to the category of 'other strategy' (Wright et al. 1991b).

## Local Anaesthesia

Pain management is an essential skill for health care providers. In recent years, new information has revolutionised approaches to pain control. The traditional concept that pain is directly proportional to the nature and extent of the injury is no longer accepted. Rather, considerable evidence documents inadequate management of children's pain, primarily due to the dentist refusal to provide analgesia (Milgrom et al. 1994). Outdated beliefs and misperceptions regarding children's pain are common among health professionals and need to be recognised and challenged. The reason for describing local anaesthesia is that many children find difficult to accept injections due to fear and anxiety, past negative experiences or pre-conditioning by others, and this may be a major reason why some children require GA. It is therefore important to highlight how this technique can be modified when dealing with children.

The use of local anaesthesia in routine dental treatment in children varies considerably around the world. A study from Finland highlighted differences between American and Finnish dentists in regards to the dentist's perception and management of pain in children (Murtomaa et al. 1996). Finnish dentists were much less likely to use local anaesthetics during restorative treatment of either primary or permanent teeth than USA dentists. Neither group of dentists routinely prescribed nitrous oxide sedation, or premedication, or post-operative pain medications. Regarding the dentists' perceptions of pain experienced by children during dental treatment, neither group rated dental treatment procedures as particularly painful or unpleasant. Most dentists found the pain reports of children credible,

yet a significant proportion (up to 67% of the USA dentists and 21% of the Finnish dentists) did not find them strongly credible (Murtomaa et al. 1996). Local anaesthesia therefore makes an important contribution to the management of pain in dentistry. A successful technique in children depends on the use of good topical anaesthesia, adequate local anaesthetic technique, and appropriate communication with the child. This approach to patient management must influence acceptability and success of local anaesthesia.

There are no techniques of local anaesthetic administration that are unique to children, however modifications to standard methods are sometimes required. These include proper positioning of the child, routine use of topical anaesthesia, slow injection, and avoidance of direct palatal injections among others. If there is a choice at which site to administer the first local anaesthetic injection, the primary maxillary molar area should be chosen first. This region is the most easily anaesthetised with the least discomfort.

The administration of pain-free local anaesthesia depends upon a number of factors that are controlled by the operator. The choice of syringe used for conventional local anaesthetic injections in children must allow aspiration both before and during the injection of the anaesthetic solution. There is evidence that inadvertent intravascular injection is more likely to occur in younger patients and positive aspirate incidences of 20% of inferior dental block injections in the 7-12 year age group have been reported (Meechan, 1997). A recent study evaluated the use of mandibular infiltration versus block anaesthesia in paediatric dentistry. This study concluded that buccal infiltration anaesthesia was effective in providing good anaesthesia for restorative work and extractions, when supplemented by interpapillary injections in mandibular primary molars regardless of age. Buccal infiltration proved effective for pulp treatment of primary first molars but not reliable in primary second molars. Finally, block anaesthesia was found to have a negative effect on the behaviour of children aged 3-5 years (Sharaf, 1997).

Inhalation Sedation: Relative Analgesia

Inhalation sedation (relative analgesia, RA or nitrous oxide/oxygen sedation) remains the most ideal technique of sedation in paediatric dentistry, with several studies supporting its use (Roberts, 1990a; Nathan et al. 1988; Shaw et al. 1996a). It is used in children that are basically cooperative but nervous or anxious about a specific thing such as local anaesthesia. Nitrous oxide (N<sub>2</sub>O) is a non-irritating, sweet smelling, colourless gas. It is relatively insoluble in the blood and is carried in the blood in physical solution only, not combining with any blood elements (Malamed, 1995g).

Relative analgesia (RA) has many significant advantages over other forms of sedation. These can be summarised as follows:

- The onset of action of RA is more rapid than that of oral, rectal, and intramuscular (IM) sedation. The onset of action of intravenous (IV) sedation will be approximately equal to that of relative analgesia.
- Peak clinical effect does not develop in most techniques for a considerable time. Only RA and IV sedation provide peak clinical actions in a time span allowing titration:

| <i>Sedation Route</i> | <i>Peak action time</i> |
|-----------------------|-------------------------|
| Oral                  | 60 min                  |
| Rectal                | 60 min                  |
| IM                    | 30 min                  |
| IV                    | 60 sec-20 min           |
| RA                    | 3-5 min                 |

- The depth of sedation achieved with RA may be altered, allowing the operator to increase or decrease the depth of sedation. This degree of control represents a significant safety feature of RA.
- Duration of the procedure can be altered at the discretion of the operator. This is different to the other forms of sedation, which have a relatively fixed duration of clinical activity.
- Recovery time from RA is rapid and the most complete of the sedation techniques. Because the body does not metabolise nitrous oxide ( $N_2O$ ), the gas is rapidly and virtually completely eliminated from the body within 3 to 5 minutes.

The major difficulties with this technique in children are two-fold: first the lack of potency of  $N_2O/O_2$  may render the technique ineffective in the management of the more apprehensive patient, and second, some children will object to the placement of the nasal mask. This is a major problem with some children and therefore some degree of cooperation is required for RA to be successful. The overwhelming majority of children receiving RA are adequately sedated at concentrations between 30% and 40%  $N_2O$  (Malamed, 1995c). Screaming and crying patients will breath through their mouth to a great degree and therefore do not receive as a great a volume of  $N_2O$  via the nasal mask. Malamed suggests holding the mask on the patient's mouth instead of the nose, so that the child inhales greater amounts of nitrous oxide (Malamed, 1995j).

One of the more unpleasant problems when using RA in children is vomiting. Although not frequent, the incidence of vomiting appears to be greater than that seen in adults, with reports quoting figures of 10.5% (Houck and Ripa, 1971) or less than 1% (Roberts, 1990b; Hallonsten et al. 1983). This is due to the lack of ability by the operator to judge the level of the patient's sedation, which may lead to over-sedation; and secondly, the greater tendency of children to mouth-breathe. Mouth breathing decreases the volume of  $N_2O$  being inhaled

and lessens the level of sedation. When the patient returns to nose breathing, the sedation level deepens. Constant fluctuation in N<sub>2</sub>O concentration is one cause of vomiting. Two techniques are available that decrease mouth breathing. First, simplest and most effective is the use of rubber dam. It prevents mouth breathing almost entirely. A second technique, in the absence of rubber dam, is to ask the child to hold some 'special water' in their mouth (and they cannot swallow it). This raises the tongue against the palate, therefore eliminating mouth breathing (Malamed, 1995j).

In summary, RA is a highly successful method to treat anxious or difficult children. Success rates in children have been quoted at 87% (Crawford, 1990), 88% (Major et al. 1981) and 90% (Hallonsten et al. 1983; Shaw et al. 1996a).

### Sedation: Other techniques

Sedation is defined as a state of depression of the central nervous system that reduces anxiety thus enabling treatment to be carried out satisfactorily. During sedation the patient is able to independently maintain his airway, the mouth open, and respond sensibly to verbal commands. In addition the patient maintains adequate function of protective reflexes such as the laryngeal reflex. The drugs used should carry a margin of safety sufficient to render unintended loss of consciousness extremely unlikely (Roberts, 1997). According to guidelines established by The American Academy of Pediatric Dentistry in 1985, patients for conscious sedation should be ASA classification I or II (see Appendix No.1). The ASA or American Society of Anesthesiologists groups each patient according to their physical status (Owens et al. 1978). Each patient should be evaluated for allergies, medications, diseases, disorders and previous hospitalisations (American Academy of Pediatric Dentistry, 1985). Economic considerations are also of importance in determining the nature of the sedative procedure to be employed. One reason for the increased use of outpatient sedation in dentistry (and medicine) has been the high cost of hospitalisation incurred by the use of GA (Malamed, 1995j). Sedation in paediatric dentistry has a failure rate considerably greater

than that seen in adults. Trapp has stated that a failure rate of 20% to 40% is not unusual in children (Trapp, 1982). More recent experience with paediatric sedation has demonstrated a 20% to 40% failure rate with oral sedation, but a 5% failure rate with IM/IV sedation (Malamed, 1995j). The routes of administration of sedative drugs of practical use in paediatric dentistry are:

- i. Oral
- ii. Rectal
- iii. Intranasal
- iv. Parenteral:
  - Intravenous (IV)
  - Intramuscular
  - Subcutaneous
  - Submucosal

### **Oral Sedation**

In regards to sedation, oral drug administration is considered the route of choice in paediatric dentistry because of its high patient acceptability. A survey carried out in USA found that apart from inhalational sedation, oral sedation was still the most popular treatment modality chosen by clinicians to treat difficult children (Nathan, 1989). One of the major advantages of oral sedation is the fact that there is no need for the use of a needle (IM, IV) or a nasal mask (RA) to produce a clinical effect. Where appropriate, the parent may administer the drug at home prior to the dental visit (Yanase et al. 1996). This practice is however, somewhat controversial because there are cases on record in which the parent has inadvertently oversedated the child (Malamed, 1995j). Younger children may not tolerate tablets and capsules well; therefore many of the drugs administered to children are available as an elixir or syrup, which may prove more palatable to the patient. Drugs that have an unpleasant taste or odour may occasionally be mixed with food or liquids (Malamed, 1995j). Other disadvantages of the oral route include prolonged effect of the drug, reliance on

patient/parent cooperation, inability to titrate, incomplete absorption of drugs from the gastrointestinal tract, inability to readily lighten or deepen the level of sedation, and dietary restrictions (Malamed, 1995j; Sams et al. 1992).

In paediatric dentistry several drugs have been tried with varied results. This is due to the continued lack of consensus among paediatric dentists regarding the selection and dosage of drugs used for sedation (Duncan et al. 1983). A list of the most frequently used drugs is presented below:

- *Chloral hydrate*: This is a sedative drug that decreases anxiety by depression of the sensory cortex (Duncan et al. 1983). It has been used alone with a reported success rate of 85% in one study (Duncan et al. 1994), or in combination with promethazine (Phenergan) with 54% success (Sams et al. 1992), hydroxyzine, nitrous oxide/oxygen or meperidine (Duncan et al. 1983) with varied success.
- *Combination of pethidine* (also called meperidine, narcotic analgesic) *and promethazine* (antihistaminic), with success rates at 45% (Alfonzo Echeverri et al. 1993) and 63% (Sams et al. 1992).
- *Ketamine*: This is defined as a dissociative anaesthetic drug with a powerful analgesic effect. Ketamine is easy to administer, its onset is quick, there is a wide safety margin and exhibits a short duration of action. Success rates have been reported at 65% (Alfonzo Echeverri et al. 1993).
- *Hydroxyzine*: This is an antihistaminic with sedative and anti-emetic properties. It has been used alone (Kupietzky et al. 1996) or in combination with chloral hydrate to reduce the incidence of nausea and vomiting (Tsinidou et al. 1992).
- *Diazepam (Valium)*: A benzodiazepine with anxiolytic, sedative, muscle relaxant and anticonvulsant effects (Houpt et al. 1996).
- *Temazepam*: A benzodiazepine and metabolite of diazepam with sedative and hypnotic effects (Tsinidou et al. 1992).

- *Midazolam (Hypnovel)*: A short acting benzodiazepine with anxiolytic, sedative, hypnotic, anticonvulsant, muscle relaxant, and anterograde amnesic effects (Kupietzky and Houpt, 1993). Success rates of 67% (Hartgraves and Primosch, 1994), 75% (Krafft et al. 1993), and between 60% and 75% depending on the oral dose have been quoted (Silver et al. 1994).

Much interest has been focused on the use of midazolam for conscious sedation in paediatric dentistry. Midazolam has been used as a pre-anaesthetic sedative in adults and more recently in children (Kupietzky and Houpt, 1993). Midazolam is currently available in the US and Australia only as an IV solution. Given orally, the drug has a distinct bad taste that is not easily disguised in juices or other clear or carbonated soft drinks. Only 15-30% of an orally administered dose of midazolam reaches the systemic circulation in its non-metabolised form due to an extensive hepatic effect (Payne et al. 1989). Thus, the oral dose should be approximately double or triple the IV dose to achieve similar clinical effects. Oral doses ranging between 0.3-0.75 mg/kg are commonly recommended (Silver et al. 1994; Hartgraves and Primosch, 1994; Kupietzky and Houpt, 1993), and the medication should be given 20-30 minutes prior to treatment.

A variety of studies have evaluated paediatric dental sedation using various drugs or drug combinations supplemented with N<sub>2</sub>O (McCann et al. 1996; Houpt et al. 1996; Houpt, 1993; Shapira et al. 1992). All sedative agents were used in doses consistent with the recognised upper limits of therapeutic ranges, and none of these studies reported any significant adverse effects, despite some probability of such.

## Rectal Sedation

The rectal route of drug administration has regained interest in anaesthesiology and to some extent in dentistry (Jantzen and Diehl, 1991). In paediatric dental general anaesthesia, it is used to administer analgesic drugs to provide post-operative pain control and as premedication prior to induction (Roelofse et al. 1990a). Advantages of the rectal route include a rapid onset of clinical activity; a decreased incidence and intensity of drug related side effects (Flaitz and Nowak, 1985), the avoidance of an injection, ease of administration, and low cost. Disadvantages of the rectal route include the inconvenience to the operator and patient, variable absorption of some drugs from the large intestine, possible irritation of the intestine, inability to reverse the action of the drug easily, prolonged recovery with some drugs, and the inability to titrate precise individual dosages (Malamed, 1995h). The primary indication for rectal drug administration in both medicine and dentistry are uncooperative patients, whether a child or adult. Signs and symptoms of sedation develop rapidly with many rectal drugs, clinical sedation being evident at 15 to 30 minutes (Roelofse et al. 1990b).

Midazolam has received considerable attention as a rectally administered drug for premedication or sedation (Roelofse et al. 1990b; Roelofse et al. 1990a; van der Bijl et al. 1991; Kupietzky and Houpt, 1993). Various doses of rectal midazolam have been used, ranging from 0.2 to 5.0 mg/kg (Malamed, 1995h). It appears that a rectal dose of approximately 0.35 mg/kg (Roelofse et al. 1990b; van der Bijl et al. 1991) to 0.5 mg/kg (Tolksdorf and Eicj, 1991; Krafft et al. 1993) provides a rapid onset of action, a high level of successful sedation (approximately between 65% and 85%), with minimal intra- or post-operative complications. Roelofse et al. observed that 23% of the 60 children receiving rectal midazolam exhibited disinhibition reactions, particularly those receiving a dose of 0.45 mg/kg. Reactions observed included agitation/excitement, restlessness/irritation, disorientation/confusion, and emotional/crying responses (Roelofse et al. 1990b). Other drugs used for rectal sedation are diazepam (Lowey and Halfpenny, 1993; Flaitz and Nowak,

1985) and ketamine with reported successful procedures in 65% of cases (van der Bijl et al. 1991).

### **Intranasal Sedation**

Intranasal drugs have been employed primarily in paediatrics as a means of avoiding the need for injection or oral drug administration in unwilling patients (Wilton et al. 1988; Saint-Maurice et al. 1990). Clinical trials have demonstrated that absorption and bioavailability of intranasal administered drugs is close to those of IV administration with peak plasma levels of the agent occurring approximately 10 minutes following administration (Rey et al. 1991). Intranasal administration of midazolam has been reported by several authors to be an effective premedication agent before general anaesthesia (Wilton et al. 1988). Fuks and coworkers suggested doses between 0.2 to 0.3mg/kg of midazolam as appropriate premedication for intranasal use in paediatric dentistry (Fuks et al. 1994). Other drugs have also been used via the intranasal route with varied success. A study compared anterograde amnesic effects of midazolam with hydroxyzine in children undergoing dental treatment plus nitrous oxide, using a recall test. This study found that midazolam was more effective in creating amnesia than hydroxyzine (Kupietzky et al. 1996). Administration of drugs via this route to children has disadvantages. These include distress to the child during instillation of the drug, bad taste of the drug (eg midazolam), and possible entry of the drug into the pharynx with coughing and sneezing. This last problem may cause expulsion of the drug with decreased absorption, and therefore unreliable onset and effect of the drug being used (Malamed, 1995i).

### **Parenteral route**

The use of the parenteral route in paediatric dentistry mainly refers to intravenous (IV) and intramuscular sedation. Although IV sedation is highly effective in adults (Malamed, 1995e; Kupietzky and Houpt, 1993), its use in children is limited. One study reported its overall use in children at only 18% (Nathan, 1989). Nonetheless, it has been suggested that used in

combination with RA, IV sedation is a safe and effective sedation modality with minimal side effects (Barr and Wynn, 1992).

There are several potential advantages of the IV route. The onset of action of IV drugs is the most rapid of all of the techniques discussed. On average the arm-brain circulation time is approximately 20 to 25 seconds. Because of this rapid onset, titration of the drug can be done to meet the specific needs of the patient. This is one of the most important safety factors associated with IV sedation. The recovery period for most IV drugs is significantly shorter than that seen for the same drug administered via the oral, rectal or other routes (Malamed, 1995e). Another advantage of the IV route is its ability to provide a degree of amnesia or a lack of recall. Whether amnesia develops or not following an IV procedure depends on several factors. Some drugs are much more likely to provide amnesia than others are. Diazepam, midazolam, lorazepam, and scopolamine are examples of drugs that have a greater degree of amnesia associated with their administration; pethidine and pentobarbital are less likely to provide an amnestic effect. The depth of sedation has an effect on whether or not amnesia develops and on the duration of the amnestic effect (Malamed, 1995e).

One major disadvantage with IV sedation is the need to insert a needle. Children may be particularly difficult to manage via this route because their veins are proportionally smaller, making the venipuncture itself more difficult. Younger children requiring IV sedation will usually pose severe management problems or be physically unable to control themselves (Malamed, 1995e). Parenteral sedation, specifically the intramuscular, subcutaneous, and submucosal routes, has been associated with an increased risk of morbidity and mortality when narcotic drugs are used (Goodson and Moore, 1983). Nevertheless, the parenteral route has been used successfully to provide sedation of young dental patients. Ketamine given intramuscularly has been reported to provide adequate sedation for dental procedures 30-40 minutes long (Okamoto et al. 1992). Also, intravenous administration of midazolam has been used with 73% success (11 out of 15 patients) in children (Schwartz et al. 1992).

However, the variability of responsiveness makes midazolam unreliable when used alone to facilitate dental treatment, and the high dose requirements make close monitoring of children mandatory (Schwartz et al. 1992).

Propofol (Diprivan™) has also been reported as an adequate drug for intravenous sedation in older children and adults. Propofol has a rapid onset of action, rapid clearance, distribution and metabolism, which make it ideal as a sedation agent. Its disadvantages are pain during injection, increased talkativeness, and cost (Rodrigo and Jonsson, 1989; Oei-Lim et al. 1991).

In summary, for those children that cannot be managed with non-pharmacological methods, sedation offers significant advantages. Whilst relative analgesia is undoubtedly the safest and simplest, there remains a group of children for whom it is inappropriate, mainly those of very young age. Other modes of sedation include oral, intranasal, rectal, and intravenous; all have some role to play but are in general somewhat unreliable or unacceptable to the paediatric patient. The result is that GA is still a necessary management tool for the treatment of children.

## **Aspects of general anaesthesia**

### ***History and Development of Anaesthesia***

The discovery of anaesthesia was one of the most important advances in medicine not only because it has alleviated the fearful pains of surgery, but also because the whole structure of modern medicine has drawn strength from its success. Surgery itself has been able to accomplish, with its aid, a greater advance in the last century than in all the preceding millennia (Armstrong, 1965). For descriptive purposes, the history of anaesthesia has been divided into three chronological subheadings and the development of day-stay surgery.

#### **The Early Days (1844-1863)**

It is reported that on December 10, 1844, in the town of Hartford, Connecticut, Professor Gardner Quincy Colton presented a popular science lecture (Armstrong, 1965; Malamed, 1995b). Professor Colton was an itinerant, travelling around the countryside presenting his show of new scientific and quasi-scientific discoveries to eager audiences. In his show nitrous oxide ( $N_2O$ ) gas was discussed and demonstrated, and members of the audience were invited to participate on the effects of  $N_2O$ . A Hartford dentist, Dr Horace Wells (1815-1848) was present during the show. At the demonstration a store clerk by the name of Samuel Cooley volunteered to receive  $N_2O$ . Cooley quickly became intoxicated and while running on the stage, his leg hit the side of a table quite hard yet he continued to carry on unaware of his injury. Wells discussed this occurrence with Professor Colton and arranged for a demonstration of  $N_2O$  at Wells's dental office the next day. At the surgery, on December 11, 1844, a reluctant Colton served as the anaesthesiologist as another dentist, Dr John Riggs, extracted a wisdom tooth from Wells. After recovering from the effects of the  $N_2O$ , Wells stated that he was unaware of the procedure and that he felt no pain. Wells was taught the process of manufacturing  $N_2O$  by Colton, and shortly thereafter began using the gas in his dental practice with great success.

Through his association with William Thomas Green Morton, Wells was able to demonstrate his technique to medical students and faculty at the prestigious Harvard Medical School. Morton, a dentist who became a student and later a partner of Wells in Hartford, eventually left dentistry becoming a medical student at Harvard. Morton was present in the audience on this fateful day. Using a medical student volunteer as a patient, Dr Wells administered  $N_2O$  to the patient through a newly developed inhaler. At this time, the bag with the gas was withdrawn much too soon, and therefore, the patient felt some pain while having a tooth extracted. The audience, assuming that the procedure had failed, proceeded to boo and hiss Wells until he was forced to leave the hall, thoroughly humiliated, his demonstration a failure. Within a year or so of his ill-fated demonstration of  $N_2O$  a discouraged Wells abandoned the practice of dentistry. On May 30, 1848, Horace Wells, later acknowledged as the founder of anaesthesia, committed suicide while in jail by cutting the femoral artery in his left thigh with a razor (Malamed, 1995b).

The practice of modern anaesthesia is frequently, and rightly, dated from the demonstration of the inhalation of ether vapour, by the dentist Morton (1819-1868). On October 16, 1846 (now called Ether Day), at the Massachusetts General Hospital in Boston USA, he successfully demonstrated its use in front of several prominent medical men. He administered ether to Gilbert Abbott, as the famous surgeon John Collins Warren excised a tumour from the jaw of Mr Abbott. Morton did not discover anaesthesia, nor was he the first person to relieve surgical pain or to use ether. However, he successfully administered the right agent, before the right people, in the right place, at the right moment in history. This ensured that the news of his success spread rapidly around the world and contributed to a revolution in the practice of surgery.

News of the discovery of anaesthesia quickly spread around the world and in a short time ether was being used for surgical operations in every civilised community. Ether was first used in England for a dental extraction on December 19th, 1846. Although it had immediate

acceptance with many there existed a number of people who opposed the introduction of anaesthesia on moral and medical grounds. Opposition was gradually overcome, largely by the influence of Sir James Y. Simpson, Professor of midwifery at Edinburgh (Armstrong, 1965). Simpson introduced ether into the practice of obstetrics for the first time in 1847. He found, however, that the smell of ether hung about his clothes, and he sought for another agent. After experimenting with chloroform, he introduced it in November of the same year. The first of a series of deaths with this agent occurred in January 1848, and the remainder of the century was occupied in a contest between the advocates of the two rival drugs (Malamed, 1995b).

The understanding and general acceptance of anaesthesia was greatly accelerated by the work of John Snow, the first physician after Morton to specialise in anaesthesia. His two books, *On the Inhalation of the Vapor of Ether* (1847) and *Chloroform and Other Anaesthetics* (1858) are considered the great classics of the literature of anaesthesia. It was his administration of chloroform to Queen Victoria at the birth of Prince Leopold in 1853 that finally overcame the opponents of anaesthesia in midwifery.

### Anaesthesia Develops (1863-1898)

The end of chloroform was in sight when nitrous oxide was re-introduced by Colton, who ever since he administered the gas to Horace Wells in 1844, had retained a belief in its efficacy. In 1863, he succeeded in opening a clinic in New York "devoted exclusively to extracting teeth with the gas" (Armstrong, 1965). By the year 1881, Colton had administered N<sub>2</sub>O to 121,709 patients without a death (Malamed, 1995b).

Although gases had been compressed into cylinders in England as early as 1856, it was not until after 1868 that this method of storage became common and the use of nitrous oxide became extensive. At the same time in Chicago, Dr Edmund W. Andrews, a physician born in Vermont, introduced the inhalation of 20% oxygen to nitrous oxide, a most significant

advance in the history of anaesthesia. In 1872, in England, liquid  $N_2O$  became commercially available making its use much more practical and considerably safer. No longer did physicians and dentists have to manufacture their own  $N_2O$  with the risk of including impurities in the gas. Elsewhere in the world, in 1881 two developments helped consolidate the use of  $N_2O$ . In St. Petersburg, Russia, an obstetrician by the name S. Klikovitsch first used  $N_2O$  as an analgesic to relieve the pains of labor. In the same year in Philadelphia, the S.S. White Company began to supply liquified  $N_2O$  to the medical and dental professions. It also introduced a machine that delivered the gas from the cylinder to the patient. By the year 1889  $N_2O$ - $O_2$  analgesia was being used in dentistry during cavity preparation in Liverpool, England. However significant side effects developed, such as nausea, vomiting and excitement, resulting in the decline of the use of  $N_2O/O_2$  analgesia through the 1890's.

### The Twentieth Century to Modern Times

Anaesthesia for general surgery in the late 19th century, relied on the more potent drugs while in dental practice, nitrous oxide persisted as the sole agent. Most administrations of nitrous oxide were by dentists or general medical practitioners rather than anaesthetists in hospitals, and consequently dental anaesthesia developed to some extent in isolation from hospital practice. Some of the problems encountered at the time were the large number of patients who required treatment, the short duration of most dental procedures, the necessity for rapid recovery and economic factors, which demanded that cost was minimal. Only the brief duration of the procedure and the comparative youth of the patients allowed this technique to persist, but popularity was the stimulus for the development of specific equipment to meet the needs of the practitioner. The nasal mask was introduced in 1899 and allowed more extended surgery. With the availability of cylinders of the gas, equipment of the 'on demand' variety was devised (1910) and has persisted in dentistry to the present day (Braid, 1989).

Pierre-Cyprien Oré of Bordeaux, France, was the first person to administer a drug intravenously (chloral hydrate) to achieve general anaesthesia in 1872. The successful use of this route in humans was made in 1903, when Emil Fisher and J. von Mering synthesised the first barbiturate, barbitone (Driscoll, 1978). This discovery gave Fisher the Nobel Prize in Medicine in 1903. In 1935 John S. Lundy at the Mayo Clinic in Rochester, Minnesota, introduced sodium thiopental. This short duration IV anaesthetic quickly became the most popular drug in the United States for the induction of general anaesthesia (Malamed, 1995d). In 1945 Niels Bjorn Jorgensen became probably the first person to use the IV route to provide what Jorgensen himself termed IV premedication (Jorgensen and Leffingwell, 1953).

### Development of Day-stay Anaesthesia

The series of events that gave impetus to the growth of day-stay (outpatient) surgery started with the beginning of the 20<sup>th</sup> century. Nicoll first documented the practice of day-stay surgery when he presented to the British Medical Association the results of 8988 operations on outpatients performed at the Glasgow Royal Hospital for Sick Children between the years 1899 and 1909 (Nicoll, 1909). Previously, many children were admitted to hospital for periods of days or weeks, for relatively simple surgical procedures. Day-stay surgery had several advantages compared to inpatient surgery: it reduced the emotional stress of the child, by not separating him/her from the family environment, it decreased the possibility of hospital acquired infections, and it reduced the cost of treatment (Steward, 1975). Since these beginnings early in the century, other events took place which slowly helped the growth of day-stay surgery. From 1916, numerous centers and facilities were opened as well as several day-stay surgical programmes by different universities across the USA (Henderson, 1991).

Despite its apparent success, it was not until the late 1960s that the technique gained wider acceptance. Children that on clinical grounds were suitable for day surgery, accounted for between one-quarter and one-third of the surgical work-load of one particular paediatric hospital, yet many surgeons still preferred to admit these patients the day before of the operation and discharged them the following morning. This was mainly due to administrative difficulties associated with day surgery (Armitage et al. 1975). During the late 1960s and 1970s, day-stay became more widely used and was reported to make for a more efficient use of the operating time and a reduction in waiting lists (McDonald, 1983; Rainey and Ruckley, 1979). The use of day-stay surgery has continued to expand since its gain in popularity in the 1970s. In the USA alone, 66% of all surgery was performed as day-stay surgery in 1994 (Korttila, 1995).

In dentistry, general anaesthesia has been traditionally in the form of a short outpatient procedure for simple extractions, often done in dental surgeries and taking no more than a few minutes to complete (Armstrong, 1965; Smallridge et al. 1990). The introduction of general anaesthesia in specialised day-care facilities, whilst avoiding hospital admission, provides a longer operating time, allowing conservative treatment or minor oral surgery to be carried out. An important advantage of this method in children is that in the majority of cases, all treatment could be provided at a single operating visit, a factor that may well contribute to the acceptability to patients and parents (Holt et al. 1991). Dental treatment under general anaesthesia has shown to be efficacious and associated with low failure rates in the restorative work carried out (O'Sullivan and Curzon, 1991; Mitchell et al. 1985).

For these reasons, day-care facilities proved to be of particular value in children who are physically, mentally or emotionally handicapped and for those with extensive treatment needs (Rule et al. 1967). More recent studies from Belgium and the United States have confirmed this finding (Enger and Mourino, 1985; Vermeulen et al. 1991; Boulanger, 1990; Bohaty and Spencer, 1992).

## ***Safety of General Anaesthesia***

Dental general anaesthesia is still a controversial topic, even though about 2 million general anaesthetics were recorded annually in the United Kingdom between 1950-1970 (Muir et al. 1976). Up until the early 1960s, it was common practice for many dentists to act as both, operator and anaesthetist. Following an apparent increase in the number of deaths resulting from general anaesthetics administered for dental treatment, the Council of the British Dental Association (BDA) reviewed the policy in relation to the operator administered general anaesthetic (Working Party Report, 1975). At the time, the number of GAs administered annually in dental practices was not known with any accuracy. During 1973 in England and Wales 1.2 million general anaesthetics were given under the National Health Service (N.H.S.). In addition, an unknown number of general anaesthetics were given in private practice. Therefore, the number of GAs administered privately may have well exceeded the number of anaesthetics administered by the N.H.S. (Working Party Report, 1975).

The BDA adopted the policy that, in the interests of the patient and of the practitioner, it was desirable that a dental or medical practitioner other than the operator should administer a general anaesthetic. As a result, the number of operator administered GAs diminished steadily from 26% (single operator/anaesthetist) in 1963, to 17% in 1968 and 11% in 1973 (Working Party Report, 1975).

## ***Morbidity and Mortality***

Morbidity and mortality statistics are used to determine the safety of sedation and general anaesthesia in the dental/medical set-up. Morbidity is defined as the ratio of sick to well in the community, whereas mortality is the relative frequency of death or death rate in a community, and it is expressed as a ratio of deaths to the total population (Delbridge and Bernard, 1995). Unfortunately, most of the surveys and studies of morbidity and mortality

related to dental anaesthesia lack specific details, which make impossible to extract information that may be helpful in reducing dental surgery mishaps (Campbell, 1986).

Day surgery has a remarkable record of safety. An American study reviewed over 45,000 consecutive day-stay procedures and concluded that the risk of major morbidity and mortality does not differ from that in similar populations undergoing overnight admission surgery (Warner et al. 1993).

### Mortality of General Anaesthesia

Mortality rates are commonly used as indices of safety when referring to GA. Several studies report on the incidence of mortality related to the use of general dental anaesthesia and these are summarised in Table 1.2 (Goldman, 1960; Bishop and Potts, 1961; Bourne, 1970; Coplans and Curson, 1973; Coplans and Curson, 1993; Coplans and Curson, 1982; Krippaehne and Montgomery, 1992; Lytle and Yoon, 1980; Nkansah et al. 1997; Tomlin, 1974). In comparison, Table 1.3 shows some studies on the mortality of medically related GAs (Alexander et al. 1965; Holland, 1987; Tired et al. 1988; Zeitlin, 1989; Warden and Horan, 1996; Working Party Report of ANZCA, 1998). The purpose of these tables is to show the relative mortality rates since the 1950s, and they are not meant to be exhaustive in nature. The often quoted mortality rate favourably comparing outpatient dental case mortality (1/137 000 to 1/860 000 quoted) with hospital anaesthetic mortality (1/10 000 to 1/19 000) is due to the fact that specific criteria for determining these ratios differs widely among authors (Jastak, 1992).

**Table 1.2:** Studies reviewing the mortality rate of dental general anaesthesia

| <i>Author(s) &amp; year</i>    | <i>Country</i>       | <i>Period of study</i> | <i>No. deaths</i> | <i>Mortality rate</i>         | <i>Deaths related to</i>              | <i>Comments</i>                                                   |
|--------------------------------|----------------------|------------------------|-------------------|-------------------------------|---------------------------------------|-------------------------------------------------------------------|
| Goldman (1960)                 | UK                   | 1952-58                | 100               | 1:219,000 GAs                 | Dental GAs                            | Halothane used successfully                                       |
| Bishop & Potts (1961)          | UK (London)          | 1939-59                | 1                 | 1:103,000 GAs                 | Dental GAs (Guy's Hospital)           | 33% of GAs given to children under 12 years                       |
| Bourne (1970)                  | UK                   | 1966-70                | 16                | -                             | -                                     | 15 deaths due to GA; 1 death due to LA                            |
| Coplands & Curson (1973)       | UK                   | 1968-71                |                   | 1:124,000                     | Dental exos                           |                                                                   |
| Tomlin (1974)                  | UK (England & Wales) | 1963-68                | 48                | 1:300,000<br>1:15,000         | Dental (private)<br>Dental (hospital) | 17 deaths occurred in hospital & 29 in private practice           |
| Lytle & Yoon (1980)            | USA                  | 1973-77                | -                 | 1:860 000 GAs between 1968-77 | Dental (private)                      | Survey of a USA Society of Oral & Maxillofacial surgeons          |
| Coplands & Curson (1982)       | UK                   | 1970-79                | 120               | 1:10,000                      | Dental (hospital)                     | 100 deaths due to GA, 10 to LA.                                   |
| Krippaehne & Montgomery (1992) | USA                  | 1977-92                | 35                |                               | Dental (private)                      | Lack of monitoring a key factor in mortality/morbidity            |
| Coplands & Curson (1993)       | UK                   | 1980-89                | 71                |                               | Dentistry or dental GAs deaths        | 4 deaths involving op/anaesthetist compared to 13 between 1970-79 |
| Nkansah (1997)                 | Canada               | 1973-95                | 4                 | 1.4:1 million                 | Dental GAs                            | Greater safety of day-stay proc.                                  |

| <i>Author(s) &amp; year</i> | <i>Country</i> | <i>Period of study</i> | <i>No. deaths</i> | <i>Mortality rate</i>                  | <i>Deaths related to</i>                       | <i>Comments</i>                                                        |
|-----------------------------|----------------|------------------------|-------------------|----------------------------------------|------------------------------------------------|------------------------------------------------------------------------|
| Alexander et al (1965)      | USA            | 1953-64                | 17                | 1.03:10 000 proced.                    | Tonsillectomy (in hospital)                    | Only one death in the last four years of the study                     |
| Holland (1987)              | Australia      | 1960-87                | 5262              | 1960 1.45:100 000<br>1984 0.44:100 000 | Deaths in NSW                                  | Approx. 5 times safer to have GA in 1987 as to 1960                    |
| Tiret (1988)                | France         | 1978-82                | 1                 | 1:40 240 GAs                           | 440 institutions; GAs done in children only    | Risk of complications significantly higher in infants than in children |
| Zeitlin (1989)              | USA            | 1955-64<br>1977-84     | 15<br>31          | 2.16:10 000 GAs<br>0.16:10 000 GAs     | Hospital figures compared to litigation claims | This suggests a 13 fold decrease in mortality between periods          |
| Warden (1996)               | Australia      | 1984-1990              | 1503              | 1:20 000 GAs<br>0.44: 100 000 pop.     | Deaths before full recovery from GA            | 172 deaths attributed to anaesthesia of which 161 were due to errors   |
| Horan (1998)                | Australia      | 1991-93                | 116               | 6.6: 1 000 000 population              | Data compiled from all States                  | Only two child deaths during study                                     |

**Table 1.3:** Studies reviewing the mortality rate of medical general anaesthesia.

In comparison to general anaesthesia, local anaesthesia is undoubtedly safer with a mortality rate of almost nil. A review of the complications of local anaesthesia did not record one death (Jorgensen and Hayden, 1965), but another study recorded three deaths between 1963-68 (Tomlin, 1974). A more recent study by Coplans & Curson found three deaths related to local anaesthesia (prilocaine with felypressin), but in all three cases death appeared to be secondary to another condition, e. g. severe cardiovascular pathology (Coplans and Curson, 1993).

A study of deaths associated with dentistry and dental disease in England and Wales showed that there were fewer deaths associated with dentistry between 1980-89 as compared to 1970-79. Whilst most of the deaths were still associated with general anaesthesia, the total number decreased from 120 to 71, as did the percentage of deaths in which general anaesthesia was thought to play a significant part (Coplans and Curson, 1993).

In Australia, a recent report found 116 anaesthesia-attributable deaths during 1991-93. When considering that 7.8 million anaesthetics were administered, the national incidence of death attributable to anaesthesia was around one per 68,000 anaesthetics. There were few deaths in young children attributed to anaesthesia, which may suggest that the standard of paediatric anaesthesia in this country is high (Working Party Report of ANZCA, 1998).

### Morbidity of General Anaesthesia

Morbidity is considered a more useful parameter than mortality when discussing complications associated with general anaesthesia, as it describes to some extent the nature of the problems encountered. Although life-threatening complications after day-stay anaesthesia are rare, discomfort that prolongs or complicates recovery is common. Follow up studies with reference to post-anaesthetic and post-operative sequelae have reported a high number of patients with post-operative symptoms (Yee et al. 1985; Smith and Young, 1976;

Ogg, 1972; Ogg et al. 1983). One study found that 78% of patients went home with symptoms such as drowsiness (46%), dizziness (40%), and/or headache (58%) (Smith and Young, 1976). Another found that patients complained about symptoms in 61% of cases (Ogg, 1972). In contrast, an Australian study found minimal morbidity following oral surgery procedures (mostly surgical removal of third molars) and a high degree of patient satisfaction (Hempnall and de Plater, 1991). Furthermore, a review comparing morbidity of general anaesthesia with local anaesthesia found little difference for outpatient dental procedures (Muir et al. 1976), although another study did show considerably fewer post-operative side effects with local anaesthesia alone (Ogg et al. 1983).

In paediatric anaesthesia, the most commonly reported complications before discharge are sore throat, headache, muscle pains, nausea and vomiting, and postoperative pain (Hannallah and Epstein, 1994). In order to describe these methodically, morbidity of paediatric outpatient anaesthesia will be divided into:

- Airway complications
- Cardiac complications
- Post-operative nausea and vomiting
- Post-operative admission following complications
- Complications related to dental treatment

### **Airway complications**

The main complications arising from the airway are laryngospasm and stridor.

*Laryngospasm:* This is usually a transient event but can be potentially life threatening. During laryngospasm, either the true vocal cords or the true and false cords become opposed in the midline and close the glottis. Thus, laryngospasm is an involuntary closure of the glottis by the intrinsic laryngeal muscles (Brett et al. 1994). A study reported on the incidence of laryngospasm during 156,064 anaesthetics delivered to 136,929 patients. The overall incidence of laryngospasm in children was relatively high compared to adults.

Children between the ages of 0 to 9 years had an incidence of 17.4 events/1000 patients compared with 8.7/1000 for the whole population. Asthma and respiratory infection were associated with an increased incidence of laryngospasm in children (Olsson and Hallen, 1984).

*Stridor:* Stridor is defined as noisy breathing secondary to turbulent flow through the narrowed lumen of an airway (Brett et al. 1994). Thus, it is a symptom of many different problems that produce a narrowed, partially obstructed airway. In general, inspiratory stridor is caused by upper airway obstruction, secondary to lesions such as laryngeal anomalies, adenotonsillar hypertrophy, midfacial hypoplasia, and croup. Expiratory stridor is most commonly associated with lower airway obstruction from lesions such as cysts, hemangiomas, vascular rings, and foreign bodies. In children, a tube that allows a slight leak of gas around is preferred during positive pressure ventilation, as this decreases the incidence and severity of post-intubation stridor or croup (Brett et al. 1994; Hannallah and Epstein, 1994). Despite proper selection of a tube, children that undergo long anaesthetic procedures can still experience post-intubation croup. This is possibly secondary to surgical manipulation of the jaw against the endotracheal tube during the surgery. Fortunately, croup that is severe enough to cause respiratory distress almost always occurs during the recovery phase rather than after discharge. Therefore many centres do not allow children to be discharged within three hours of tracheal extubation (Hannallah and Epstein, 1994).

### **Cardiac complications**

The most common cardiac complications in children associated with day-stay dental general anaesthesia are cardiac dysrhythmias and bacterial endocarditis. A dysrhythmia is any deviation from the normal sinus rhythm of the heart. A high incidence of cardiac dysrhythmias during GA for minor oral surgery has been reported in the past (Fisch et al. 1969; Thurlow, 1972; Ryder and Townsend, 1974). Dysrhythmia was reported as the most common intraoperative complication occurring in 112,721 patients at a major teaching

hospital (Cohen et al. 1986). These dysrhythmias appear to be due to the beta effects of catecholamines acting on a myocardium sensitised by halothane. Unpremedicated children undergoing dental extractions with a halothane/nitrous oxide/oxygen anaesthetic have also been noted to experience cardiac dysrhythmias (Thurlow, 1972; Plowman et al. 1974; Haden, 1985). These have been attributed to light anaesthesia, elevated endogenous catecholamines (especially likely in the highly nervous patient), lack of pre-operative anticholinergic medications, and trigeminal stimulation (Vermeulen et al. 1991; Plowman et al. 1974; Thurlow, 1972; Miller et al. 1970).

The interruption of afferent surgical stimuli by infiltration with local anaesthetic appears to be effective in significantly reducing the incidence of cardiac dysrhythmias. This confirms that surgical stimulation is an important aetiological factor in producing dysrhythmias during general anaesthesia with nitrous oxide/oxygen and halothane, for oral surgery (Plowman et al. 1974). Other precipitating factors for dysrhythmias include carbon dioxide retention (hypercarbia), tracheal intubation (especially when the patient is in a light plane of anaesthesia), anoxia or severe hypoxia, and the duration of the GA procedure. Occasionally, disturbances of cardiac function may occur with the introduction of throat packs, or they may be associated with the placement of props or gags (Braid, 1989).

The need for antibiotic prophylaxis in children with heart disease undergoing dental treatment is well recognised (Berry, Jr. et al. 1973b; Berry, Jr. et al. 1973a). The incidence of bacteremia in children has been found to be higher when nasotracheal intubation is used. A study comparing ways of intubation found that 16% of children had bacteremia with nasotracheal intubation, whereas no bacteria could be detected in those with orotracheal intubation (Berry, Jr. et al. 1973a). Bacterial invasion into the blood circulation occurs due to traumatic nasotracheal intubation and is more likely to occur in patients with poor oral hygiene and extensive dental procedures (Morrow et al. 1986). Because of this higher incidence of bacteraemia associated with nasal versus oral intubation as well as the high

incidence of bacteraemia following dental restoration and extraction, it is imperative that children with congenital heart disease be given prophylactic antibiotics to prevent subacute endocarditis. Appendix 2 provides guidelines for prophylaxis of bacterial endocarditis followed at the Westmead Dental Clinical School (Cameron and Widmer, 1997).

### **Post-operative nausea and vomiting**

Nausea and vomiting are the most frequently reported postoperative complications. The cause and frequency of postoperative vomiting are complex because there are many associated variables (Oh and Davis, 1990). The aetiology and incidence of nausea and vomiting associated with general anaesthesia have been reviewed in the literature (Palazzo and Strunin, 1984). These authors stated that, in the absence of antiemetics, the incidence of emetic difficulties is approximately 30%. Factors implicated included gender, fasting, elevated catecholamines levels, opiates, excessive ventilation via a face mask, pain, hypotension, and rough handling of the patient. The incidence of nausea immediately post-operatively was 22% with a 6% incidence of actual vomiting (Palazzo and Strunin, 1984). These figures compare favourably with the findings of others where an incidence of nausea approaching 50% with 22% vomiting was not uncommon (Yee et al. 1985; Smith and Young, 1976; Ogg et al. 1983).

The incidence of nausea and vomiting varies also with the type and length of the surgery performed. Intractable vomiting is commonly associated with tonsillectomy and adenoidectomy (Ahlgren et al. 1971) and with strabismus surgery (Abramowitz et al. 1983). Vomiting is twice as common after operations that last more than 20 minutes compared to those that take less than 20 minutes. The frequency of vomiting in intubated, unpremedicated children who receive nitrous oxide/halothane anaesthesia for strabismus can be as high as 80% (Abramowitz et al. 1983). Other studies have shown lower incidence of vomiting in patients under 3 years of age and a high incidence in premedicated patients (Rowley and Brown, 1982).

The ability to drink clear liquids without vomiting after anaesthesia and surgery is a commonly used criteria for discharge of paediatric surgery patients. A study of 989 child patients undergoing day-stay GA found that 14% of the children that were allowed to drink during the recovery period vomited (group called 'elective' drinkers), as compared with 23% of those children that were required to drink prior to discharge ('mandatory' drinker group). This difference was statistically significant as was the more prolonged stay in the recovery unit by the group of mandatory drinkers. This study concluded that it was unnecessary to make drinking a prerequisite for discharging paediatric patients after day surgery (Schreiner et al. 1992).

### **Post-operative admission following complications**

Unexpected hospital admission following outpatient surgery has become an important measure of outcome in day-stay surgical care. Moreover, unexpected admission to the hospital reflects unanticipated patient morbidity and disrupts the smooth management of day-stay surgical practices (Gold et al. 1989). One per cent of all patients require hospital admission following day-stay surgery (Steward, 1975; Patel and Hannallah, 1988; Gold et al. 1989). One survey of 9616 adult patients who underwent day-stay surgery found that the likelihood of unanticipated admission was related to the type of anaesthesia and surgical procedure rather than to any patient characteristics (Gold et al. 1989).

Postoperative admission rates between 0.9% and 2.6% following dental procedures have been quoted (Vickers and Goss, 1983; Yee and Davis, 1984). This last study found that these admissions were not the result of any single anaesthetic or surgical misadventures, but due to the procedure being more complicated or traumatic than expected (Vickers and Goss, 1983). In addition to severe vomiting, the most common reasons for unplanned admission in paediatric outpatient anaesthesia are postoperative croup, fever bleeding, sleepiness, family requests, and surgical complications (Oh and Davis, 1990; Hannallah and Epstein, 1994).

### **Complications related to dental treatment**

The main complications arising from dental procedures under general anaesthesia include airway maintenance related problems (both with and without the presence of an endotracheal tube), cardiac dysrhythmias associated with dental procedures (already discussed), postoperative pain, and subcutaneous emphysema.

*Airway maintenance:* The benefits of tracheal intubation via the nasal route include better surgical access to the oral cavity, easier fixation and greater patient comfort if intubation is to continue into the postoperative period. One study reported on the pathological changes associated with short-term nasal intubation in 100 patients undergoing dental extractions under general anaesthesia. Minor bruising was common (reported incidence of 54%) and most frequently involved mucosa overlying the inferior turbinate and adjacent septum. There was no relationship between the number of attempts at intubation and subsequent damage. Overall, results showed that there was no significant nasal morbidity, and pre-operative assessment failed to identify those in whom nasal intubation proved difficult or impossible (O'Connell et al. 1996). Nasal intubation can be traumatic when nares are congested or constricted, and bleeding may be excessive. Adenoidal tearing and bleeding may occur, with the additional danger of carrying debris and microorganisms into the trachea and lungs (Berry, Jr. et al. 1973a). If the endotracheal tube is forced against the nostril, a pressure spot followed by a disfiguring scar may result. Although this complication is of little danger, it has the potential to upset the patient (Smith, 1990). Placement of a throat pack may stimulate cardiac arrhythmias, constrict the endotracheal tube, or lead to postoperative pharyngeal irritation, hoarseness or both (Smith, 1990), however this is rarely of major relevance. Another complication of endotracheal intubation is the likelihood of damage to the teeth or lips by the laryngoscope while securing an airway for adequate ventilation of the patient. Such damage formed the basis for one third of all confirmed or potential anaesthetic claims notified to one medical protection society in the UK (Chadwick and Lindsay, 1996;

Chadwick and Lindsay, 1998). Similar studies restricted to child dental anaesthesia have not been reported.

*Postoperative pain:* Little is known about postoperative pain in children following extraction of teeth under GA. Analgesic requirements of children following dental surgery are highly variable and postoperative analgesics are administered to children less frequently than to adults (Abu-Saad, 1984), probably due in part, to the difficulty in evaluating pain in children (Moore et al. 1985). There is evidence from studies of adults following the removal of impacted third molars, that postoperative pain is highest on the day of surgery, but the precise pattern of pain and the timing of maximum pain intensity varies (Chapman, 1988; Fisher et al. 1988). However, whether the severity and timing of any pain after less invasive procedures in children follows the same pattern is unknown. One prospective study investigated factors influencing postoperative pain in children undergoing extractions under general anaesthesia. The most significant factor appeared to be the relationship of the accompanying adult to the child: children attending with their mothers were more likely to complain of postoperative pain. Pain was reported by 57.5% of children immediately after treatment, indicating that the need for postoperative analgesia may be helpful and should be given immediately after the procedure (Fung et al. 1993).

*Subcutaneous emphysema:* Air driven (approximately 30 psi of pressure) ultra high speed dental handpieces and the use of air syringes (20-25 psi.) can cause subcutaneous emphysema in the facial and cervical areas that may extend into the mediastinum and result in pneumothorax, pneumomediastinum, pneumopericardium, and intravascular air embolism (Milne et al. 1982; Rosenberg et al. 1979). Reports of subcutaneous emphysema in children undergoing general dental anaesthesia have occurred in long restorative sessions, ranging from 1.5 to 4 hours (Rosenberg et al. 1979; Levy, 1981). However this complication would appear to be rare.

Several other problems may arise during the delivery of dental treatment to children under general anaesthesia.

- Dislocation of the temporomandibular joint occurs not infrequently in children if the mouth is opened widely. It predisposes to airway obstruction by altering the position of the tongue and its occurrence should alert the anaesthetist to the possibility of obstruction. Reduction of the dislocation is usually readily obtained and long term sequelae is rare (Braid, 1989).
- Particular care must be taken with the insertion of mouth props as deciduous teeth can be easily dislodged (Braid, 1989).
- Cotton rolls placed between cheeks and teeth may obstruct the salivary ducts and cause painful swelling of the parotid glands (Smith, 1990).

### ***Anaesthesia: drugs and monitoring***

Despite the current popularity of outpatient surgery, there is still no agreement among anaesthetists as to what constitutes the best way to ensure smooth induction of, and rapid and comfortable recovery from anaesthesia without compromising safety. A particular agent or technique should be chosen and tailored to fit the needs of the individual child, not used merely because it is routine in a particular institution or is the only method with which the anaesthetist is comfortable (Hannallah and Epstein, 1994). The use of general anaesthesia in paediatric dentistry involves either inhalational or intravenous induction of anaesthesia. A short description of the drugs most commonly used in children is given below.

#### **Inhalational Induction of Anaesthesia**

Inhalational induction refers to the use of gaseous agents to bring about the state of anaesthesia. A successful inhalational induction of anaesthesia requires the child's cooperation and acceptance, especially in the outpatient environment where premedication is

not always used. There are several inhalational anaesthetics available for use in dental anaesthesia, and the four most commonly used agents will be discussed in brief.

### **Nitrous Oxide**

Nitrous oxide ( $\text{NO}_2$ ) is a non-irritating, sweet-smelling, colourless gas. It is the only non-organic compound other than  $\text{CO}_2$  that has any CNS depressant properties and is the only inorganic gas used to produce anaesthesia in humans.  $\text{NO}_2$  is relatively insoluble (coefficient of 0.47 at 37° C) in the blood and is carried in physical solution only, not combining with any blood elements. Nitrous oxide has the great advantage of being practically odourless, which makes it suitable for starting inhalational induction in the paediatric patient. Unfortunately, this gas has limited potency (minimum alveolar concentration of 105%), and for that reason it is usually supplemented with potent inhalational or IV anaesthetics (Hannallah and Epstein, 1994).

### **Halothane**

Halothane is a halogenated hydrocarbon with a blood/gas partition coefficient of 2.3 and has a characteristic 'sweet' odour. It is nonflammable which allowed the use of electrocautery by the surgeon and the introduction of extensive electronic monitoring by the anaesthetist. It is a potent agent capable of inducing any depth of anaesthesia required. Due to its poor analgesic properties, halothane is most often used with nitrous oxide or a narcotic analgesic (Malamed, 1995a). It is widely used in children due to its low cost, good patient acceptance, ease of administration, and lack of irritant effects on the airways (Olsson, 1995). For the outpatient it offers the advantage of a rapid, smooth induction, either by direct inhalation (accompanied by nitrous oxide) or after induction with an IV agent. Initial use of high inspired concentrations (up to 3%) speeds the induction of anaesthesia; however, this is quickly reduced to the usual maintenance range of 0.5 to 2% (Hannallah and Epstein, 1994).

Disadvantages of halothane include myocardial depression, cardiac dysrhythmias, sensitisation of the myocardium to the actions of catecholamines, and hepatotoxicity among others (Malamed, 1995a). Recovery after brief halothane anaesthesia is usually rapid and uneventful. Nausea and vomiting are not common. However, recovery time is longer with prolonged administration. Although there is a tendency to avoid repeated use of halothane in adult outpatient anaesthesia for fear of sensitising the liver and possibly inducing hepatic necrosis with future exposure, it is generally believed that this is rarely a problem in the preadolescent child (Smith, 1980).

### **Isoflurane**

Isoflurane is a chemical isomer of enflurane (Ethrane). Isoflurane has a pleasant odour, it is non-irritating (produces no secretions), it is a bronchodilator, it provides excellent muscle relaxation, it keeps the cardiac rhythm stable, it is compatible with adrenaline and it is non-flammable (Malamed, 1995a). It has a low blood/gas solubility coefficient, which should make induction of anaesthesia and postoperative recovery more rapid than with halothane. Isoflurane, like enflurane, tends to provoke more excitement, breath holding, coughing and laryngospasm during induction than halothane (Hannallah and Epstein, 1994).

### **Sevoflurane**

Sevoflurane, a fluorinated ether with low blood solubility (0.63) is the newest inhalational anaesthetic available for both induction and maintenance of anaesthesia in paediatric outpatients. Its pleasant, non-irritating odour and lack of pungency allow a rapid increase in inspired concentration during induction and therefore a rapid onset. Recovery from short anaesthetics after sevoflurane appears to be fast and to be associated with minimal side effects (Hannallah and Epstein, 1994). Sevoflurane has negligible airway irritant effects, which facilitates a "smooth" induction, even in comparison with halothane in paediatric patients, and makes it particularly suitable for rapid induction of anaesthesia in adults and children. Emergence, orientation and postoperative cognitive and psychomotor function

recovery of paediatric outpatients is significantly more rapid from sevoflurane than from halothane anaesthesia (Patel and Goa, 1996; Kataria et al. 1996). Sevoflurane is well tolerated by adult and paediatric patients during induction of anaesthesia, with a low incidence of mild airway complications (breath-holding, coughing, excitement and laryngospasm). During rapid induction, it is better tolerated than isoflurane or halothane (Patel and Goa, 1996).

### **Intravenous induction of Anaesthesia**

Intravenous induction (IV) of anaesthesia is the method of choice in older children, as it ensures a rapid, pleasant induction with minimal struggling and no unpleasant memories of a suffocating mask or a smelly gas. The real limitation to the more frequent use of IV induction in children is the anaesthetist's attitude and experience. It is likely that, with the availability of short acting IV agents such as propofol, the use of topical anaesthetics (e. g. EMLA) to minimise discomfort during venipuncture (Soliman et al. 1988), and the increased concern about the level of wasted inhalational agents, the use of IV anaesthesia may become more common in the future. At present, the two most commonly used drugs for intravenous induction are thiopentone followed by halothane in 30% oxygen and 70% nitrous oxide, and propofol followed by maintenance boluses of the same drug with 30% oxygen and 70% nitrous oxide (Puttick and Rosen, 1988).

### **Thiopentone**

Thiopentone is a short-acting barbiturate with potent anaesthetic properties. It provides poor analgesia but the induction period is smooth and very quick. Thiopentone as a 2.5% solution is a common induction agent for adult outpatient anaesthesia. In a dose of 4 to 5 mg/kg it is equally suitable for children (Hannallah and Epstein, 1994). Toxic reactions and side effects include respiratory depression, apnea (cessation of breathing >20 seconds), coughing and laryngospasm. Brochospasm may occasionally develop in asthmatic patients. In a standard concentration of 2.5%, thiopentone (due to the high alkalinity of the solution and the

chemical nature of the drug) is irritant to tissue, and intra-arterial injection or extravasation may result in tissue necrosis.

A study comparing the recovery time after thiopentone induction and inhalational induction in children found that half an hour after surgery there was no difference in the recovery score between the two groups. However, children induced with a barbiturate agent (e. g. thiopentone or methohexital) tended to be sleepier and required more airway support for the first 15 minutes of the recovery period. Also, there was no difference in the eventual return to a "bright and alert" status and normal appetite at home after discharge from hospital (Steward, 1975).

### **Propofol**

Propofol (2,6 diisopropylphenol) is a short acting hypnotic considered the most suitable intravenous drug available for the anaesthetic management of outpatients. Propofol is presented as an emulsion in soybean oil (Diprivan™), a vehicle that supports bacterial growth, therefore extreme caution with asepsis is required. It offers many advantages, including rapid onset and very prompt and pleasant recovery, with minimal nausea and vomiting (Hannallah and Epstein, 1994). The induction dose in healthy children is reported to be around 3 mg/kg. Unfortunately, propofol administration is associated with a high incidence of pain and burning sensation when small hand veins are used for injection. The incidence of pain on injection has been reported to be as high as 31% when the veins on the dorsum of the hand are used, as compared to 8% when the antecubital veins are used (Valtonen et al. 1988; Hannallah et al. 1991).

### **Monitoring during general anaesthesia**

Monitoring of appropriate physiological functions of a patient, during both sedative procedures and general anaesthesia, allows the early detection of adverse side effects that

may be produced by drugs or by clinical actions. The purpose of monitoring is to detect potential problems. It is not a substitute for close clinical observation by the anaesthetist, who must maintain constant contact with the patient and continuously evaluate and integrate all incoming information (Gregory, 1994a). While human error is responsible for about 86% of preventable anaesthetic mishaps, equipment failure has accounted for approximately 14% of the morbidity and mortality of general anaesthesia (Cooper, 1978). Proper assessment of the paediatric patient undergoing anaesthesia involves cardiovascular, respiratory, temperature and other type of monitoring (Gregory, 1994a):

- *Cardiovascular monitoring:* Monitoring of the pulse, heart rate and rhythm is recommended for all patients as a part of the routine pre-operative evaluation. Monitoring at regular intervals is desirable in all sedation techniques, usually at intervals of 15 or 5 minutes depending on the amount of CNS depression. In general anaesthesia, continuous monitoring is mandatory. The heart rate and rhythm may be measured manually or by electronic methods. At present, pulse monitors, such as the pulse oximeter (see later) allow continuous monitoring of the heart rate, and they are preferred over other devices (Malamed, 1995f). The electrocardiogram (ECG) is also an important adjunct to cardiac monitoring in the operating room, as infants and children frequently become bradycardic during anaesthesia (Gregory, 1994a). General anaesthetics decrease the blood pressure of infants and children more than that of adults. Children also tend to lose blood relatively more rapidly than adults. Consequently, blood pressure should be monitored in all patients. For this measurement to be accurate in children, the blood pressure cuff must be an appropriate size for the patient (Gregory, 1994a).
- *Respiratory monitoring:* Of at least equal if not greater importance than monitoring of cardiovascular function during general anaesthesia is monitoring of respiration. Because the drugs used to provide general anaesthesia are CNS and respiratory depressants, changes in breathing will usually be observed well before the cardiovascular changes are

noted (Malamed, 1995f). Clinically unsuspected hypoxia occurs considerably more frequently than was thought prior to introduction to oximetry (Cote et al. 1991; McKay and Noble, 1988). A study of 402 paediatric anaesthetics concluded that the pulse oximeter is far superior to either the capnograph (see later) or clinical judgement in providing the earliest warning of desaturation events (Cote et al. 1991). The use of pulse oximetry has become a standard of care during general anaesthesia, whether for inpatients or outpatients (Malamed, 1995f; Rosenberg and Campbell, 1991). Pulse oximeters enable the anaesthetist to monitor oxygenation continuously and they accurately reflect the saturation of oxygen ( $\text{SaO}_2$ ) of infants and children of all ages when the  $\text{SaO}_2$  is above 70%. It is much less accurate in hypoxic infants (Costarino et al. 1987). Monitoring end-tidal gases gives early warning of changes in oxygen, carbon dioxide, and anaesthetic concentrations (Gregory, 1994a). The capnography device monitors the levels of inspired and end tidal  $\text{CO}_2$ , providing visual displays as percentage or millimetres of mercury. Response is virtually instantaneous, assessing every breath taken by the patient. Currently, the most ideal monitoring system for ventilation appears to be the combination of pulse oximeter and capnography (Aka and Jedrychowski, 1995).

- *Temperature:* It is important to determine the temperature prior to the start of anaesthesia, as fever increases the workload of the cardiovascular and respiratory systems. The heart rate increases with increased temperature as does the rate of respiration, and the patient's ability to tolerate stress decreases. The importance of monitoring temperature during general anaesthesia is based on the need to prevent severe hypothermia, and to monitor for the possible development of malignant hyperthermia (Malamed, 1995f).
- *Other:* Monitoring parameters such as metabolic function, urine output, blood loss, or intracranial pressure are also required in certain circumstances. However, the need to use

them during a typical outpatient dental procedure on an ASA I or II patient is questionable (Malamed, 1995f). Such techniques are not relevant to this review and can be found in the literature (Gregory, 1994a).

## Monitoring and Dentistry

Physiological monitoring of patients is essential in assuring the success and safety of sedation. However appropriate monitoring practices in dentistry are not widespread. A report comparing 43 cases of morbidity and mortality from pharmacosedation in dentistry found that complications occurred in young healthy patients, in whom multiple drug agents were used with limited monitoring and resuscitative efforts. Heart rate was *not* monitored in 68%, respiration in 77%, blood pressure in 77%, tissue oxygen saturation in 92%, and heart rhythm in 97% (Krippaehne and Montgomery, 1992). The authors concluded, and others agreed, that lack of adequate monitoring is a key factor in the majority of morbid and mortal events (Krippaehne and Montgomery, 1992; Jastak, 1992). Furthermore, a survey of monitoring practices of 261 American paediatric dentists revealed that the most frequently used methods were clinical observation, pulse oximetry, and precordial stethoscope. However, most paediatric dentists (87%) who used sedation did not involve a separate operator to deliver sedation/anaesthesia (Aka and Jedrychowski, 1995).

Pulse oximetry for monitoring children in dentistry has been found to detect oxygen desaturation faster than conventional methods such as clinical observation. The results of a study showed that children sedated with 50 mg/kg chloral hydrate and 25 mg hydroxyzine in conjunction with 40 percent nitrous oxide and 60 percent oxygen may have respiratory difficulties which are not detected by the traditional monitoring of blood pressure, pulse, respiratory rate and skin colour. The use of a pulse oximeter that noninvasively measures oxygen saturation of hemoglobin (SaO<sub>2</sub>) allowed earlier detection of respiratory distress than the other methods mentioned (Whitehead et al. 1988).

## ***Special considerations of paediatric general anaesthesia***

Day-stay surgery has improved tremendously in the last twenty years, and paediatric patients are now provided with care that is similar to that available to in-patients, without an increased risk of morbidity and mortality. Improved anaesthetic drugs and techniques, better monitoring equipment, and an increased awareness and understanding of the psychological and physiological differences between paediatric and adult patients have helped to maintain the safety statistics (Campbell et al. 1982).

Paediatric anaesthesia as a subspecialty has evolved because the needs of infants and young children are fundamentally different from those of adults. Many of these important differences, however, are not obvious. Although the most apparent contrast is size, physiological differences related to general metabolism and to immature function of the various organ systems (including heart, lungs, kidneys, liver, blood, muscles, and central nervous system) are of major importance to the anaesthetist (Motoyama, 1990a). The purpose of describing these differences between children and adults is to highlight some of the difficulties encountered when providing general anaesthesia to children. Dentists involved in the care of children under GA should be aware of the demands imposed by child patients under day-stay procedures. This section highlights some of these differences and more comprehensive explanations can be found in textbooks of paediatric anaesthesia (Gregory, 1994b; Motoyama and Davis, 1990b).

### **Anatomical and physiological differences in children**

The most obvious anatomical difference between children and adults is the ratio of body surface area to mass. Body surface area expressed as calories per hour per square meter, is considered to be the best criteria for determining drug dose, basal metabolic rate, and fluid and nutritional requirements. Although body surface area may be difficult to use clinically, it

can be said generally that if a child is growing within the 90<sup>th</sup> percentile, when he or she reaches 2 years of age, the surface area-mass ratio is approximately double that expected at full growth potential. The approximate weight and height can also be helpful in predicting the clinical response to drugs. The smaller the patient, the higher are the basal metabolic rate, the fluid requirements per hour, the oxygen consumption per minute, and the energy carbohydrate metabolism (Campbell et al. 1982).

Fluid maintenance and replacement is dependent upon body weight and total body water, as reflected by blood volume and extracellular fluid compartments. Total body water (TBW), calculated at about 80% of the body weight, is composed of extracellular fluid (ECF) and intracellular fluid (ICF). Children have approximately equal percentages of ECF and ICF (about 40% each), while adults during the process of growth and development lose about 50% of the ECF while maintaining the same ICF. Therefore, children have a larger ECF compartment than the adult patient. This will influence the pharmacokinetics of drugs used in outpatient general anaesthesia (Campbell et al. 1982). Approximately 10% of the TBW is in the blood volume, and this is calculated on the basis of body weight. In the child, up to the age of about 3 years, the blood volume is about 80 ml/kg, whereas in the adult it is about 70 ml/kg. This difference allows children to tolerate larger blood losses without change in clinical cardiovascular parameters (blood pressure and heart rate). Their blood volumes are larger and their peripheral vasculature responds better to fluid changes. However, this apparent advantage is often offset by reduced haemoglobin concentrations from ages 2 to 14 (Campbell et al. 1982). Children experience rapid fluid exchanges that can be reflected in periods of overhydration or relative dehydration. The latter is an important consideration as fasting is required prior to general anaesthesia. Dehydration can lead to hypotension on induction with anaesthetic agents. Rehydration in children, apart from replenishing proper fluid volume, may also minimise a febrile response during recovery.

Brain size and muscle mass are important anatomical differences to consider in children. Approximately 20% of the child's body weight consist of muscle mass, compared with 40% in the adult (Campbell et al. 1982). This difference may be related to the incidence of malignant hyperthermia, an uncommon genetic disorder that has been estimated to occur in children undergoing anaesthesia at a rate of 1:17,000 cases, compared with a 1:35,000 incidence in adults (Britt and Kalow, 1970). Therefore, there appears to be an inverse relationship between percentage of muscle mass and malignant hyperthermia. The brain size in the child gradually changes with increasing age. It occupies approximately one quarter of the total body surface area in infancy, and the ratio changes to 1:8 (brain/body surface) in the adult. Inhalational anaesthetic agents are transported to, and occupy a larger volume in the brain with respect of body mass, and result in quicker onset of action and more profound effect in children than in adults (Campbell et al. 1982).

### Respiratory system differences

The child's upper and lower respiratory tract anatomy, which is different in size and function compared with the adult, can decrease the margin of safety in the child patient. The narrow nasal passages and glottic opening, commonly hypertrophied tonsils and adenoids, larger tongue, greater volume of secretions, and the narrowing of the trachea at the cricoid level can predispose the patients to respiratory obstruction. Upper airway obstruction, from a nasal mask constricting the nares, displacement of the tongue posteriorly, or depression of the floor of the mouth by an improperly placed mouth pack or retractor, will further accentuate the smaller anatomical features in a child. Generally, deeper anaesthetic planes with inhalational agents decrease the incidence of turbulent air flow caused by the smaller anatomical structures in the child patient. This is important but not as crucial in the adult, when intravenous agents are used and the larger airways can allow greater turbulence in airflow and lighter planes of anaesthesia (Campbell et al. 1982).

Lung volumes in infants, relative to body size, are similar to those in older children and young adults. These values increase in linear fashion with body growth. However, the ratio of alveolar surface area in the lungs to lung size is proportionally greater in children, allowing for greater alveolar ventilation per unit area. Greater alveolar ventilation is necessary for an adequate response to increased metabolic rate and oxygen consumption. The absolute values of lung functions in children, including functional reserve capacity (FRC), tidal volume (TV), vital capacity (VC), and alveolar ventilation (AV), are smaller even though the respiratory frequency is higher. The FRC, defined as the volume of gas remaining in the lungs at the end of a normal respiration and consisting of residual volume and expiratory reserve volume, is an important determinant of the speed of induction with inhalational anaesthetics as well as the speed of onset of hypoxia. The ratio of AV to FRC is significantly different in children compared with adults. The alveolar ventilation transports inhalational agents to the brain, while the portion of the gas remaining in the lung occupies the functional residual volume during normal breathing. In conjunction with a higher respiratory rate, this ratio difference helps explain the speed of induction in children. Because of the smaller FRC, if a child becomes obstructed or apnoeic, hypoxia can occur more rapidly than in adults (Campbell et al. 1982).

### Cardiovascular system differences

General anaesthesia for the young patient with a structurally normal heart is often simpler than that for an older adult. This is because in infants and children cardiovascular stress responses are well established, coronary artery disease is rare, and life-threatening arrhythmias seldom occur. However, three considerations present the anaesthetist with special challenges: the normal cardiovascular physiology of paediatric patients without heart disease changes dramatically with age; the patient may have a congenital cardiac malformation; and, volatile and intravenous anaesthetic agents may have unique and adverse haemodynamic effects in the newborn infant. Details of these can be found elsewhere (Schieber, 1990).

In children, the cardiac rate is the most important determinant of cardiac output (Schieber, 1990). A sudden decrease in heart rate also results in a significant decrease in cardiac output, which in turn increases the rate of uptake of an inhalational anaesthetic agent. Since 40% of the cardiac output of the child patient (almost twice that of the adult) contributes to the cerebral blood flow, an increase in anaesthetic uptake during the slower perfusion of the pulmonary system causes a profound depressant effect. In general terms, changes in the heart rate and output are better compensated in a child than in the adult patient because of the larger extracellular fluid compartment and blood volume (Campbell et al. 1982). Cardiac output is high in children and blood flow is more directed to vessel rich tissues. The shorter induction period in children also increases the risk of obtaining a high concentration of inhalational agent in the myocardium and, consequently, in children some degree of systemic arterial hypotension is commonly seen during inhalational anaesthesia. However, a moderate fall in blood pressure due to loss of consciousness and stress, or due to a decrease in systemic vascular resistance, is seldom a major disadvantage in children (Olsson, 1995).

### Pharmacological considerations

Pharmacokinetics, the process of absorption, rate of uptake distribution, localisation in tissues, biotransformation and elimination are all better understood in adults than in children. Many factors affect the pharmacodynamics of drugs. They include ionisation, lipid solubility, plasma binding, rate of metabolism, potency, tolerance of the specific agents, size of body water compartments and cardiac output and its relative distribution to the tissues (Campbell et al. 1982).

Minimum alveolar concentration (MAC) is defined as the concentration of an inhalational anaesthetic agent that prevents muscular movement in response to painful stimuli in 50% of patients. This indirectly indicates anaesthetic potency and is often influenced by age (MAC requirements decrease with increasing age), metabolic rate, and adjunctive drug therapy (Campbell et al. 1982).

Several important differences between adults and children can be identified in the area of pharmacology and paediatric anaesthesia:

- *Elevated anaesthetic requirement.* Children require larger doses of inhalational anaesthetics and relative larger doses of intravenous agents than adults to achieve the same effect. It has been hypothesised that this phenomenon may be related to a higher systemic metabolic rate or the larger water content of the young brain (Gregory, 1994c).
- *Rate of induction with inhalational agents.* The minute ventilation per kilogram of children is much greater than that of adults. In addition, the functional residual capacity per kilogram weight of the paediatric lung is significantly smaller. In light of these two facts, the basis for the important observation that children experience a more rapid inhalation induction of GA has been attributed to respiratory function (Gregory, 1994c).
- *Inhalational anaesthetic-vasoconstrictor interaction.* Dentists commonly use local anaesthetics containing vasoconstrictor agents such as adrenaline for control of post-operative pain or intra-operative haemostasis. These vasoconstrictors are cardiac stimulants that on occasion will cause cardiac arrhythmias. Inhalational agents such as halothane are also known to increase cardiac irritability and predispose to vasoconstrictor-induced arrhythmias when administered to adults. Children however, seem to be less susceptible to this drug interaction than adults (Karl et al. 1983). Other agents such as enflurane and isoflurane have less potential for cardiac irritability than halothane, and are acknowledged as safer for use with vasoconstrictors in older children and adults (Trapp, 1987).

## Psychological considerations

Children scheduled for dental surgery under general anaesthesia quite often have already experienced emotionally traumatic dental visit(s) at which time their behaviour was unmanageable. Thus, a fear of doctors and health care environments may already have developed. The young child also has a normal fear of separation from parents and has not yet developed the communication skills that allow management by reassurance (Trapp, 1987).

Parental behaviour management is also an important consideration when paediatric anaesthesia is being planned. The presence of the parents during induction has been associated with both an increase or a decrease in emotional disturbance for the child (Steward, 1975; Campbell et al. 1982). However, some authors agree that in the majority of cases, the presence of one of the parents reduces the child's fear and apprehension during induction of anaesthesia (Campbell et al. 1982) (Nathan, 1989; McCormick and Spargo, 1996).

### ***Guidelines and Regulations***

The provision of general anaesthesia in dentistry is currently regulated by organisations or bodies specifically formed to monitor and improve safety and delivery of dental anaesthesia, each one addressing the needs for a particular institution, region or country. The most influential bodies affecting the provision of general anaesthesia for dentistry in Australia are:

- Australian and New Zealand College of Anaesthetists
- American Academy of Pediatric Dentistry
- Poswillo Report (United Kingdom)

#### **Australian and New Zealand College of Anaesthetists**

The provision of sedation and general anaesthesia for dental procedures is dependant on guidelines written by the Australian and New Zealand College of Anaesthetists, in association with the Royal Australasian College of Dental surgeons (Australian and New Zealand College of Anaesthetists, 1996). A number of policy documents from this College should be noted where appropriate in conjunction with this report (see Appendices No. 3, 4, 5 and 6). These include:

- Guidelines for the care of patients recovering from anaesthesia (Australian and New Zealand College of Anaesthetists, 1995a).

- Guidelines for the perioperative care of patients selected for day care surgery (Australian and New Zealand College of Anaesthetists, 1995b).
- Monitoring during anaesthesia (Australian and New Zealand College of Anaesthetists, 1995c).
- Recommended minimum facilities for safe anaesthetic practice in dental surgeries (Australian and New Zealand College of Anaesthetists, 1995d).

### American Academy of Pediatric Dentistry

Guidelines for the elective use of conscious sedation, deep sedation, and general anaesthesia in paediatric patients were adopted jointly by the American Academy of Pediatric Dentistry and the American Academy of Pediatrics in 1985 (American Academy of Pediatric Dentistry, 1985). In June 1992, the American Academy of Pediatrics published a new document on paediatric sedation independently. The Sedation Subcommittee of the AAPD Clinical Affairs Committee, recognising the advances in monitoring technology and availability of new pharmacological agents, authored a revision of the 1985 guidelines in 1993 (American Academy of Pediatric Dentistry, 1993).

The 1993 revision requires continuous monitoring by an "appropriately trained individual". Continuous monitoring of oxygen saturation by oximetry, heart and respiratory rates, and blood pressure is required. These should be recorded intermittently on a time-based record. A pulse oximeter, precordial/pretracheal stethoscope, and blood pressure cuff are minimum monitoring devices; ECG, capnography, and temperature monitoring are desirable during sedation procedures. The child's head position should be checked frequently to ensure airway patency. Access to a defibrillator is desirable. Airway management and breathing equipment must be checked prior to each patient use. When general anaesthesia is being administered, drugs necessary for the treatment of malignant hyperthermia must be readily available. This must include sodium dantrolene which is the drug of choice for such a

condition. Patients receiving day-stay general anaesthesia must have an intravenous line in place, or have a person immediately available to establish one in paediatric patients (American Academy of Pediatric Dentistry, 1993).

After treatment has been completed, the patient must be observed in a suitably equipped recovery facility. This facility must have functioning suction apparatus and suction catheters of appropriate size, as well as the capacity to deliver greater than 90% oxygen and provide positive pressure ventilation for paediatric patients. The patient must remain in the recovery facility until cardiovascular and respiratory stability are ensured and appropriate discharge criteria have been met (American Academy of Pediatric Dentistry, 1993).

### Poswillo Report (United Kingdom)

The Poswillo Report of March 1990 named after Professor D.E. Poswillo, Chairman of the Working Party, received praise for its efficient and careful analysis of the question of general anaesthesia, sedation and resuscitation in dental practice outside hospitals (Poswillo, 1990). The report was prepared for the Standing Dental Advisory Committee in April of that year and did not have immediate acceptance. This was due to the financial implications of the 60 recommendations for dental practice. Not only were dental practices providing general anaesthesia required to be registered and regularly inspected, but they were also required to purchase additional monitoring equipment, arrange for regular maintenance, service and periodic replacement of this equipment (Leader, 1991).

The Working Party encouraged dentists to advise patients of the benefits of alternative techniques to GA, such as inhalational and intravenous sedation. Throughout the report, the importance of trained auxiliary personnel was stressed, and the authors expressed concern that too few dental assistants in private practice received any formal training (Poswillo, 1990).

In regards to monitoring and equipment, the following recommendations were included in the report:

- An electrocardiogram, a pulse oximeter and a non-invasive blood pressure device are essential during monitoring of general anaesthesia.
- A capnograph be used where tracheal anaesthesia is practised.
- A defibrillator must be available.
- Equipment conforming to recognised standards should be purchased and installed, regularly serviced and maintained in accordance with the manufacturer's instructions.

As a result of this report, the number of general anaesthetics provided in private dental practices decreased due to the financial implications of such a document. Other recommendations included ongoing training for all dentists involved (and their teams) in resuscitation procedures, advanced life support skills for all dental anaesthetists, availability of all drugs listed in the report, and provision of written instructions to patients. Full description of this report can be found in the relevant paper (Poswillo, 1990).

## Paediatric dentistry & general anaesthesia

### *Day-stay GA in paediatric dentistry*

Several authors have published results on the use of general anaesthesia for paediatric dentistry. These have been listed in chronological order and they are summarised in Table 1.4. It is obvious from this table that most papers reporting on the use of general anaesthesia in children originate from the United Kingdom. Studies from Europe (Boulanger, 1990; Roeters and Burgersdijk, 1985; Tarjan et al. 1990; Vermeulen et al. 1991) and Scandinavia (Grytten et al. 1989; Persliden and Magnusson, 1980) have also been reported. It is interesting to note that most studies from North America are from the period between 1970s and 1980s (Enger and Mourino, 1985; Leagault et al. 1972; Lisagor, 1978; Nafiz, 1976), and only one study include more recent data (Bohaty and Spencer, 1992). Reports from Australia and New Zealand are few (Watson, 1979; Chippendale and Storey, 1988; Thomson, 1994). In summary, it is clearly seen that the use of GA in paediatric dentistry is far more common in the UK, Europe, and Scandinavia than the USA. In the US, sedation in one form or another seems to be the technique of choice when dealing with very young or uncooperative patients (Wright et al. 1991b).

Most of the studies confirm that the indications for treatment under general anaesthesia are extensive decay, behaviour management problems, medically compromised patients, extensive treatment, very young age, handicapped patients, anxiety, distance from home to a dentist, and a combination of these. The average number of patients treated *per* year in these reviews varied from 4 to 7852, but most papers do not give details as to how frequently services are provided. Several papers do not report clearly details of the dental procedures carried out (Boulanger, 1990; Holt et al. 1991; Keniry, 1974; O'Brien and Suthers, 1983; Ventura et al. 1981). Some studies show a trend toward more complex procedures and preventive items being provided (Bohaty and Spencer, 1992; Enger and Mourino, 1985;

Mitchell et al. 1985). One study reported changes over a ten year period and found a trend toward fewer restorations and pulpotomies, and more extractions, stainless steel crowns, and fissure sealants (Bohaty and Spencer, 1992). Some of the studies quoted in Table 1.4 were not included anywhere else, and they are listed here for proper referencing (Whitehead, 1971; Robertson and Ball, 1973; Barclay, 1974; Drummond et al. 1996; Mansson and Schroder, 1996; Shaw and Weatherill, 1996; Bryant et al. 1997).

Table 1.4: Studies reviewing the provision of paediatric general anaesthesia in dentistry.

| Author(s)<br>and year      | Country        | Period of<br>study  | Total No.<br>patients | Day-stay<br>No. patients | Mean age/<br>range | Type of<br>treatment          | 2 <sup>nd</sup> GAs<br>(% pts.) | Comments                                                     |
|----------------------------|----------------|---------------------|-----------------------|--------------------------|--------------------|-------------------------------|---------------------------------|--------------------------------------------------------------|
| Rule et al. (1967)         | UK             | 1959-65             | 225                   | 225                      | 2-15 years         | Rests. & Exos                 | 3.5 %                           | Retrospective study of 6 year period; 32% cases were 0-5 yrs |
| Whitehead (1971)           | UK             | 1967-70             | 764                   | 761                      | 5-69 years         | Rests. & Exos<br>Surgical tx. | Not known                       | 72% between ages 10-29;<br>increased demand for GA           |
| Legault et al.<br>(1972)   | Canada         | 4 years             | 300                   | 300                      | 5.8 years          | Rests. & Exos                 | 10.7 %                          | Private clinic; no follow up in<br>27.6%; comprehensive tx.  |
| Robertson & Ball<br>(1973) | UK             | 1970-72             | 100                   |                          | 3-Adult            | Rests. & Exos                 | Not known                       | GAs for handicapped patients;<br>73% between ages 3-16       |
| Barclay (1974)             | New<br>Zealand | 1970                | 431                   | 362                      | 0-Adult            | extractions                   | Not known                       | Survey of all NZ dentists in 1970                            |
| Keniry (1974)              | UK             | '6-month<br>period' | 1,307                 | 1,307                    | 0-16 years         | comprehensive                 | 17.7 %                          | Peak ages 4-8 years; approx. 2.3<br>extractions/patient      |
| Nafiz et al. (1976)        | USA            | 84 weeks            | 80                    |                          | 1.5-16<br>years    | Rests. & Exos                 | Not known                       |                                                              |

Table 1.4 (Continuation): Studies reviewing the provision of paediatric general anaesthesia in dentistry.

| Author(s)<br>And year           | Country          | Period of<br>study | Total No.<br>patients | Day-stay<br>No. patients  | Mean age/<br>range          | Type of<br>treatment | 2 <sup>nd</sup> GAs<br>(% pts.) | Comments                                                 |
|---------------------------------|------------------|--------------------|-----------------------|---------------------------|-----------------------------|----------------------|---------------------------------|----------------------------------------------------------|
| Lisagor (1978)                  | USA              | 1975-76            | 4                     | ?                         | 2-25 years                  | Rests. & Exos        | Not known                       | Combination of medical/dental procedures                 |
| Watson (1979)                   | Australia        | 1946-78            | 808                   |                           | 2-50 years                  | Rests. & Exos        |                                 | Cerebral palsy patients; 396 patients aged between 5-18  |
| Persliden &<br>Magnusson (1980) | Sweden           | 1976-79            | 352                   | 352                       | 0-16<br>(6.5 median)        | Rests. & Exos        | Not known                       | Low morbidity (1.3%) of GA in hospital set-up            |
| Ventura et al.<br>(1981)        | Israel           | 1972-78            | 4,000                 | All?                      | 2-12 (average<br>5.0 years) | Rests. & Exos        | Not known                       | Duration ranged 40-210 mins.; deals with GA technique    |
| O'Brien & Suthers<br>(1983)     | Australia        | 12 year<br>period  | 1,316 (in<br>surgery) | 1,316                     | 1-15+ years                 | Rests. & Exos        | Not known                       | 50% of children aged 3-5 yrs; approx. 95% under 15 years |
| Enger & Mourino<br>(1985)       | USA              | 1977-82            | 200                   | ? Average<br>stay: 2 days | 7.7 years                   | Rests. & Exos        | Not known                       | Trend towards more complex treatment and prevention      |
| Mitchell et al.<br>(1985)       | UK               | 1979-83            | 96                    | 96                        | 6-25+ years                 | Rests. & Exos        | 7.2 %                           |                                                          |
| Roeters &<br>Burgersdijk (1985) | Nether-<br>lands | 1968-80            | 215                   | ?                         | -                           | Rests. & Exos        | 10.2 %                          | Majority intellectually handicapped children             |

Table 1.4 (Continuation): Studies reviewing the provision of paediatric general anaesthesia in dentistry.

| Author(s)<br>And year          | Country                  | Period of<br>study | Total No.<br>patients | Day-stay<br>No. patients   | Mean age/<br>range   | Type of<br>treatment           | 2 <sup>nd</sup> GAS<br>(% pts.) | Comments                                                                                   |
|--------------------------------|--------------------------|--------------------|-----------------------|----------------------------|----------------------|--------------------------------|---------------------------------|--------------------------------------------------------------------------------------------|
| McLaughlin et al.<br>(1987)    | UK                       | 1960-84            | 4771                  | 4771                       | 1-79 years           | Extractions<br>in 99% of cases | Not<br>known                    | Greater proportion of GAS for<br>children                                                  |
| Chippendale &<br>Storey (1988) | Australia<br>(Melbourne) | 1977-86            | Not<br>mentioned      | Not<br>mentioned           | 1-7 years            | Extractions                    | Not<br>known                    | 80% decline in GAS since<br>fluoridation                                                   |
| Grytten et al.<br>(1989)       | Norway                   | 1975-83            | 1,067                 | 1067 (private<br>practice) | 0-Adult              | Rests. & Exos                  | Not<br>known                    | Little change during period;<br>60% were aged <15 yrs                                      |
| Boulanger (1990)               | Belgium                  | -                  | 46                    | 46                         | 1.5-14 years         | Rests. & Exos.                 | Not<br>known                    | 2 main groups: below 6 yrs<br>and older than 6                                             |
| Smallridge et al.<br>(1990)    | UK                       | 1987-88            | 3,623                 | 836 (sample<br>used)       | 0-16 (mean<br>age 7) | Extractions                    | 5.0 %                           | Mean age has decreased, and<br>the number of exos/child has<br>increased; increased demand |
| Tarjan et al.<br>(1990)        | Hungary                  | 1981-89            | 180                   |                            | 2-16 years           | Rests. & Exos                  |                                 |                                                                                            |
| Holt et al. (1991)             | UK                       | 1989               | 103                   | 103                        | 9 (+/-4.4yr)         | Rests. & Exos;<br>surgical tx. | Not<br>known                    | Effective and efficient way for<br>some children; low morbidity                            |

Table 1.4 (Continuation): Studies reviewing the provision of paediatric general anaesthesia in dentistry.

| Author(s)<br>And year         | Country        | Period of<br>study   | Total No.<br>patients     | Day-stay<br>No. patients  | Mean age/<br>range           | Type of<br>treatment            | 2 <sup>nd</sup> GAs<br>(% pts.) | Comments                                                                                          |
|-------------------------------|----------------|----------------------|---------------------------|---------------------------|------------------------------|---------------------------------|---------------------------------|---------------------------------------------------------------------------------------------------|
| O'Sullivan &<br>Curzon (1991) | UK             | 1984-87              | 80                        | 80                        | 2-11<br>(4.5 median)         | Rests. & Exos                   | 2.5 %                           | 80% of children accepted tx.<br>under LA at later visits                                          |
| Vermeulen et al.<br>(1991)    | Belgium        | 1983-88              | 933                       |                           | 1-79 years<br>(median=10)    | Rests. & Exos                   | Not<br>known                    | Most patients treated were<br>children; increased demand                                          |
| Bohaty & Spencer<br>(1992)    | USA            | 1978-80<br>1988-90   |                           |                           | 6 (0-12 yrs)<br>6 (0-12 yrs) | comprehensive                   | Not<br>known                    | Trend to fewer rests. & more<br>exos.; age shift from 0-3 to 4-6                                  |
| Holt et al. (1992)            | UK             | 1990-91              | 7,852                     | 7,852                     | 0-15+ years                  | Extractions (at<br>3 hospitals) | Not<br>known                    | Demand for GA is high; nearly<br>1/3 <sup>rd</sup> of all GAs in children<br>under 5 years of age |
| Thomson (1994)                | New<br>Zealand | 1989-94              | 406                       | 406                       | 1.5-16 years                 | Rests. & Exos                   | 4.2 %                           | Demand has greatly increased;<br>extraction was most common                                       |
| Mason & Holt<br>(1995)        | UK             | 1972, 1982<br>& 1992 | 202, 287,<br>465 respect. | 202, 287,<br>465 respect. | 0-15+ years                  | Rests. & Exos;<br>surgical tx.  | Not<br>known                    | Demand has increased; more<br>radical approach in younger<br>children needed                      |
| Nunn et al. (1995)            | UK             | 1983-93              | 265                       | 264                       | 0-26+ years                  | Rests. & Exos                   | 12 %                            | Increased demand; need for<br>radical approach under GA                                           |

Table 1.4 (Continuation): Studies reviewing the provision of paediatric general anaesthesia in dentistry.

| Author(s)<br>And year        | Country | Period of<br>study        | Total No.<br>patients                   | Day-stay<br>No. patients                | Mean age/<br>range   | Type of<br>treatment                         | 2 <sup>nd</sup> GAs<br>(% pts.) | Comments                                                                                       |
|------------------------------|---------|---------------------------|-----------------------------------------|-----------------------------------------|----------------------|----------------------------------------------|---------------------------------|------------------------------------------------------------------------------------------------|
| Drummond et al.<br>(1996)    | NZ      | 3-year<br>period          | 48                                      | 48                                      | Children<br>(ages ?) | Rests. & Exos                                | Not known                       | 41% parents made no changes<br>to diets or oral care post GA                                   |
| Mansson &<br>Schroder (1996) | Sweden  | Not stated                | 117                                     | ?                                       | Children<br>(ages ?) | Rests. & Exos                                | -                               | Two-year follow up; most<br>children aged 6 or less                                            |
| Shaw & Weatherill<br>(1996)  | UK      | 1990<br>1992              | 2,408<br>3,617                          | 6,025                                   | 1-14 years           | Extractions                                  | Not known                       | Exos for 5 year olds or younger<br>has changed from 44 to 38%;<br>orthodontic exos more common |
| Bryant et al.<br>(1997)      | UK      | 1973, 1983,<br>1993, 1994 | 180, 504,<br>1348, 1352<br>respectively | 178, 503,<br>1129, 1105<br>respectively | -                    | Dentoalveolar<br>& maxillofac.<br>procedures | Not known                       | Expansion of day-stay facilities<br>needed                                                     |
| Wong et al. (1997)           | UK      | 1985-95                   | 586                                     | 566                                     | 0-17 years           | Rests. & Exos                                | 14 %                            | Trends of patients travelling<br>longer for treatment                                          |
| Harrison &<br>Roberts (1998) | UK      | 1991-96                   | 1063                                    | ?                                       | 1-24 years           | Rests. & Exos                                | Not known                       | More extractions in chronically<br>sick children                                               |

**Characteristics of children undergoing GA in dentistry**

Several studies report on the use of general anaesthesia in paediatric dentistry at major teaching hospitals or institutions (Bohaty and Spencer, 1992; Boulanger, 1990; Holt et al. 1991; O'Sullivan and Curzon, 1991; Thomson, 1994). Most children attending these institutions are first assessed in a paediatric outpatient clinic. This assessment usually includes a medical history, clinical and radiographic examinations and appropriate tests or investigations if medically compromised. A provisional treatment plan is usually formulated and advice on prevention is given to the parents. The characteristics of these children are discussed in several studies, with the most relevant topics of interest shown in Table 1.5.

| Patient details  | Demographic characteristics | Treatment provided  | Other               |
|------------------|-----------------------------|---------------------|---------------------|
| Gender           | Place of residence          | Extractions         | Medical condition   |
| Age              | Reason of referral          | Primary dentition   | Follow up           |
| Ethnicity        | Source of referral          | Secondary dentition | Need for further GA |
| Health insurance | Waiting time                | Surgical procedures | GA morbidity        |

**Table 1.5:** Characteristics of children undergoing general anaesthesia for dentistry.

Most studies agree that the main reason for providing GA in children is caries or its effects (Holt et al. 1991; Holt et al. 1992; Mason et al. 1995; McLaughlin et al. 1987; O'Sullivan and Curzon, 1991; Smallridge et al. 1990; Vermeulen et al. 1991). Only seven studies provided data on the number or percentage of patients requiring GA due to caries, and these are summarised in Table 1.6.

| Authors & Year             | No.<br>patients | Caries<br>(% patients) |
|----------------------------|-----------------|------------------------|
| McLaughlin et al. (1987)   | 4771            | 99%                    |
| Smallridge et al. (1990)   | 836             | 95%                    |
| Holt et al. (1991)         | 103             | 68%                    |
| O'Sullivan & Curzon (1991) | 80              | 84%                    |
| Vermeulen et al. (1991)    | 904             | 83%                    |
| Holt et al. (1992)         | 7852            | 86%                    |
| Shaw & Weatherill (1996)   | 559             | 54%                    |

**Table 1.6:** Percentage of patients treated under general anaesthesia due to caries.

The source of referral of children requiring treatment under GA varies extensively with the country of origin of the study involved. A major determinant is the health care system in force for each place. For instance, in the UK where most dentistry is carried out through the National Health Service (NHS), most referrals are from GP dentists as well as the School Dental Service (Mitchell et al. 1985; Smallridge et al. 1990; Holt et al. 1992; Nunn et al. 1995). In contrast, the study from Belgium found that GP dentists and doctors made the most important referral groups, followed by self referred patients (Vermeulen et al. 1991). Details of the referral patterns were available for a few studies, and these are shown in Table 1.7.

| Authors<br>& Year           | Referral patterns of patients (%) <sup>*</sup> |             |     |      |         |       |
|-----------------------------|------------------------------------------------|-------------|-----|------|---------|-------|
|                             | No. patients                                   | GP dentists | SDS | Self | Doctors | Other |
| Keniry<br>(1974)            | 1,307                                          | 52          | 13  | 32   | 1       | 2     |
| Mitchell et<br>al. (1985)   | 96                                             | 47          | 33  | 6    | 6       | 7     |
| Smallridge<br>et al. (1990) | 836                                            | 54          | 23  | 15   | -       | 8     |
| Vermeulen<br>et al. (1991)  | 889                                            | 45          | 1   | 18   | 28      | 8     |
| Holt et al.<br>(1992)       | 7,852                                          | 52          | 23  | 16   | -       | 8     |
| Nunn et al.<br>(1995)       | 265                                            | 44          | 28  | 5    | 12      | 10    |
| Wong et al.<br>(1997)       | 586                                            | 52          | 15  | 15   | 8       | 5     |

Table 1.7: Source of referrals for children requiring dental general anaesthesia.

<sup>\*</sup> Note that percentages quoted are approximations only

In regards to the treatment provided under GA, there appears to be an increasing trend to implement more radical treatment plans for this specific group of children (Nunn et al. 1995). Several studies report an increase in the number of teeth being extracted and a decrease in the number of restorations, at least in the primary dentition. The restorative procedures that were most successful in terms of durability were stainless steel crowns and pulpotomies in the primary dentition (O'Sullivan and Curzon, 1991). This is consistent with studies on the longevity of restorations in the primary dentition (Messer and Levering, 1988; Roberts and Sherriff, 1990; Kilpatrick, 1993). Results of treatment provided in the permanent dentition show that amalgam is still the material of choice when restoring permanent molars. GA is also used with frequency for the extraction of permanent teeth, either carious or for orthodontic reasons. A summary of findings of treatment provided is seen in Table 1.8. The data in this table however presents several difficulties. In some cases the standard deviations for each value were nearly as large as the value itself for a determined parameter. Secondly, several studies did not distinguish between primary and

secondary dentitions and, it is not clear how some of these values were calculated, that is, out of the total number of patients in the whole study or the total number of patients receiving that particular procedure.

| Authors<br>& Year                | No.<br>pts. | Mean<br>age | Mean number per patient |             |                    |              |     |        |     |
|----------------------------------|-------------|-------------|-------------------------|-------------|--------------------|--------------|-----|--------|-----|
|                                  |             |             | 1ry<br>exos             | 2ry<br>exos | 1ry<br>rests       | 2ry<br>rests | SSC | Pulpot | FS  |
| Rule et al.<br>(1967)            | 225         | ?           | 3.8                     | 2.8         | 3.5                | 4.4          | -   | -      | -   |
| Leagault<br>et al. (1972)        | 300         | 5.8         | 2.1<br>(1ry & 2ry)      |             | 4.1<br>(1ry & 2ry) |              | 1.1 | 0.6    | -   |
| Enger &<br>Mourino<br>(1985)     | 200         | 7.7         | 3.7<br>(1ry & 2ry)      |             | 6.1<br>(1ry & 2ry) |              | 3.0 | 0.7    | -   |
| O'Sullivan<br>& Curzon<br>(1991) | 80          | 4.5         | 4.0<br>(1ry & 2ry)      |             | 2.7<br>(1ry & 2ry) |              | 2.6 | 1.8    | 0.8 |
| Bohaty &<br>Spencer<br>(1992)    | -           | 6.0         | 4.8<br>(1ry & 2ry)      |             | 5.9<br>(1ry & 2ry) |              | 7.4 | 5.6    | 1.2 |
| Thomson<br>(1994)                | 406         | 5.1         | 3.5<br>(1ry & 2ry)      |             | 2.9<br>(1ry & 2ry) |              | -   | -      | -   |
| Nunn et al.<br>(1995)            | 265         | ?           | 3.6                     | 2.9         | 3.5                | 5.0          | -   | 1.0    | 4.0 |
| Wong et al.<br>(1995)            | 586         | ?           | 2.4                     | 0.5         | 2.7                | 1.0          | 0.1 | 0.4    | -   |

**Table 1.8:** Summary of studies that provide comprehensive paediatric dental treatment. Figures given as mean procedure per child.

**Abbreviations:** number of patients (No. pts); primary (1ry); secondary (2ry); extractions (exos); restorations (rests); stainless steel crowns (SSC); pulpotomy (pulpot); fissure sealants (FS).

Surgical procedures carried out in children varied significantly in the proportion of patients requiring such treatment. The most common procedures appeared to be surgical removal of supernumerary teeth, surgical exposures of impacted/unerupted teeth, and minor soft tissue surgery. A summary of the studies that reported surgical treatment in children is given in Table 1.9.

| Authors & Year          | No. pts.<br>in study | No. surgical<br>procedures | Procedures performed                                                     |
|-------------------------|----------------------|----------------------------|--------------------------------------------------------------------------|
| Rule et al. (1967)      | 225                  | 26 (11.5%)                 | Not stated; age range between 5-15 yrs                                   |
| Keniry (1974)           | 1,307                | 17 (1.3%)                  | Not stated; age range between 6-14 yrs                                   |
| Holt et al. (1991)      | 103                  | 46 (44.7%)                 | Mostly surgical exposures (20), supernumeraries (11) and extractions (9) |
| O'Sullivan et al (1991) | 80                   | 1 (1%)                     | Not stated. Mostly restorative and simple extractions carried out.       |
| Mason et al (1995)      | 954                  | 212 (22.2%)                | 200% increase of surgery related to orthodontics between 1982-1992       |
| Wong et al (1997)       | 586                  | 100 (17.1%)                | Supernumeraries, apicectomy, cyst removal and diagnostic implant         |

**Table 1.9:** Frequency of surgical procedures carried out in children under general anaesthesia.

**Abbreviations:** number (No.); patients (pts.)

Significant proportions of children that require GA are medically compromised or have a physical or intellectual handicap. The literature reports that between 6% (Leagault et al. 1972) and 79% (Harrison and Roberts, 1998) of children have some medical or a disability background. However, this wide variation highlights the fact that many studies do not give specific details of the actual background of these children. For instance, a child that may suffer from mild episodic chronic asthma may be grouped as a chronically sick patient, and perhaps included with other more severe medical conditions (such as cyanotic cardiac defects, severe metabolic disorders or oncology patients). A summary of the proportion of children with medical backgrounds is given in Table 1.10.

| Authors & Year               | No. patients<br>in study | % patients |
|------------------------------|--------------------------|------------|
| Rule et al. (1967)           | 225                      | 22%        |
| Leagault et al. (1972)       | 300                      | 6%         |
| Keniry (1974)                | 1,307                    | 20%        |
| Persliden & Magnusson (1980) | 352                      | 17%        |
| Enger & Mourino (1985)       | 200                      | 41%        |
| Grytten et al. (1989)        | 1,067                    | 14%        |
| Holt et al. (1991)           | 103                      | 31%        |
| O'Sullivan & Curzon (1991)   | 80                       | 20%        |
| Vermeulen et al. (1991)      | 933                      | 34%        |
| Holt et al. (1992)           | 7,852                    | 8%         |
| Nunn et al. (1995)           | 265                      | 68%        |
| Wong et al. (1995)           | 566                      | 60%        |
| Harrison & Roberts (1998)    | 1,063                    | 79%        |

**Table 1.10:** Proportion of patients with medical conditions per study.

## **Paediatric Dentistry in Australia**

### ***Dental Caries of children in Australia***

The prevalence of caries in Australian children has decreased markedly since its peak in the 1950s. Australian children, like many children in industrialised countries had considerable experience of caries in the post-Second World War period. By 1977 considerable improvement in caries experience had already occurred (Spencer et al. 1994). Data on the dental health of Australian school children who are registered with the school dental services have been reported for the period 1977 to 1986 (Carr, 1988; Commonwealth Department of Health, 1987). Significant features included a continued decline in caries experience as defined by the number of decayed, missing and filled teeth in both the primary dentition (dmft index) and permanent dentition (DMFT index). A change was also noted in the distribution of caries experience within the child population in Australia, with increasingly smaller percentages of children accounting for greater proportions of total disease experience (Davies et al. 1997).

Figures 1.1 to 1.5 have been taken from a recent study on the trends in dental experience of school children in Australia (Davies et al. 1997). Figure 1.1 presents the caries experience for both primary and permanent dentition for school children aged 5 to 12 years for 1993. The mean dmft for 5-year olds was 1.80. There was a slight increase across age groups until a peak at 8 years (dmft = 2.21). Primary caries experience then declined across older age groups as exfoliation of deciduous teeth, especially primary molars which are more likely to have caries, becomes more pronounced. The mean DMFT increased across age groups to a mean of 1.10 by the age of 12 years. However, it is readily apparent that most caries occurs between the ages of 5 and 12 years and is associated with the primary rather than the permanent dentition (Davies et al. 1997).

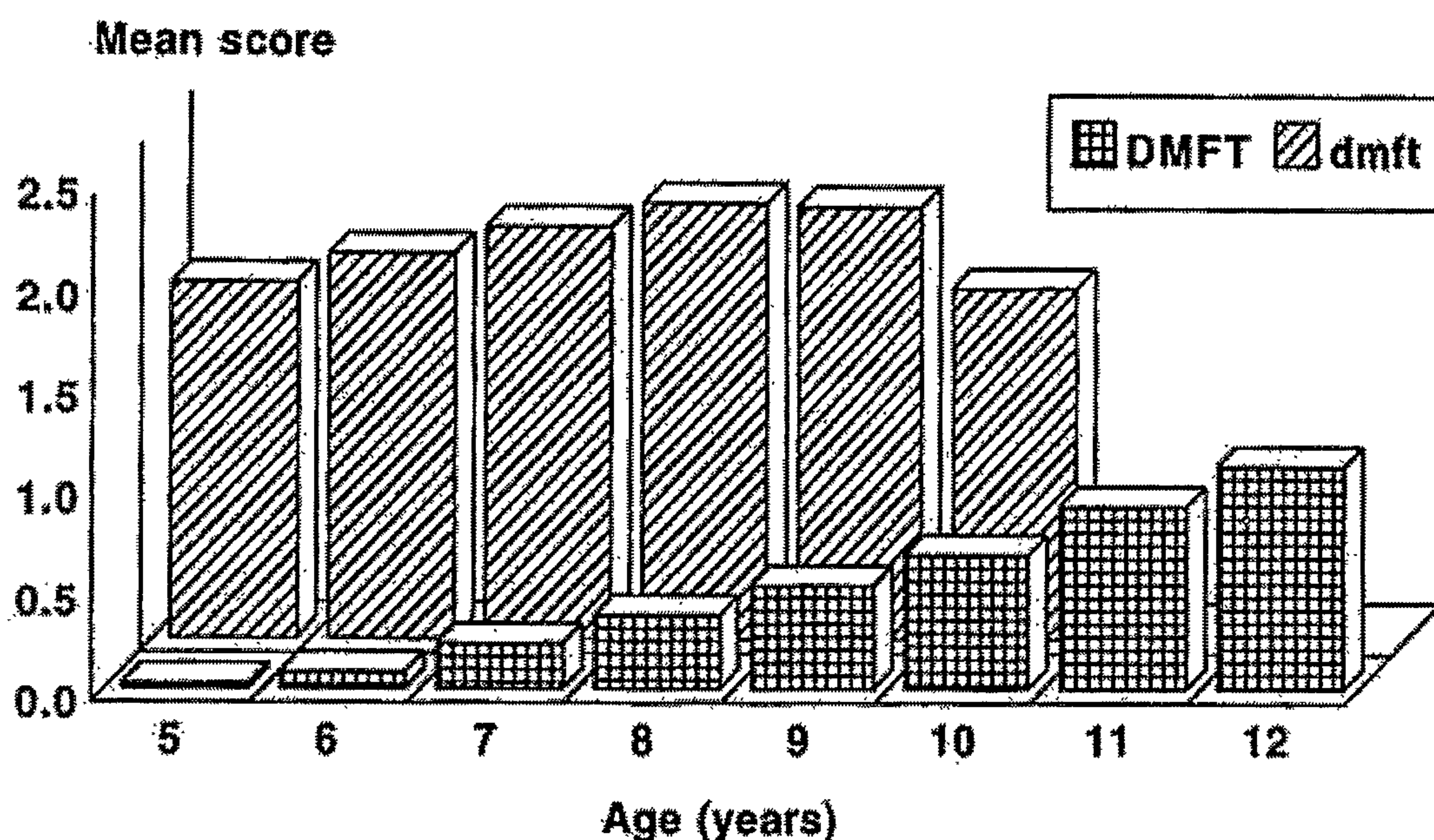


**Figure 1.1:** Mean dmft and DMFT scores for children aged 5 to 12 years in Australia in 1993. Victorian 11-12 year old children excluded due to small sample, dmft scores plotted only to age 10. Figure reproduced from study by *Davies, Spencer, et al. 1997*.

Figures 1.2 and 1.3 compare data for 1993 to previous years by presenting the 1993 caries experience for 6 and 12 year olds as part of a time trend from 1977 to 1993. Caries experience for 6-year old children was 3.13 in 1977 which declined to a dmft of 1.90 by 1993. There were no significant differences (rate of decline in caries) in mean dmft scores between 1986 and 1993. It can also be seen that caries in the primary dentition is dominated by untreated decayed teeth, although that domination reduced from 1977 to 1993. There were low numbers of teeth missing due to caries. In contrast, there was a continued decline of the DMFT index in 12-year olds over the period 1977 to 1993. The DMFT for 12-year olds was 4.79 in 1977, which declined to 1.10 by 1993 (Davies et al. 1997).

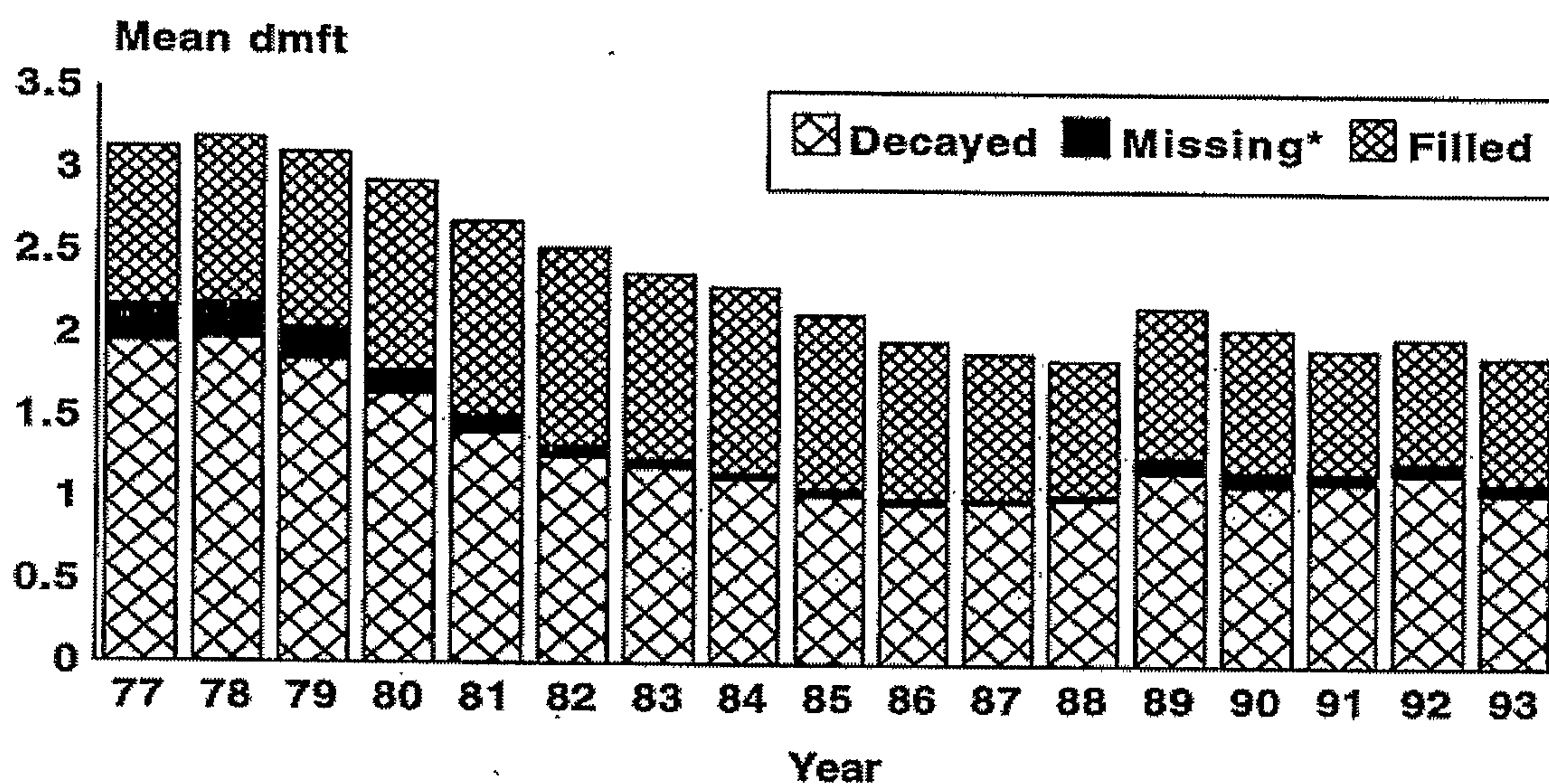


**Figure 1.2:** Mean dift and dmft components in 6 year old children in Australia from 1977 to 1993. The “i component” in dift refers to teeth ‘indicated’ for extraction from the period between 1977-1988; dmft for 1989-1993. Figure reproduced from study by Davies & Spencer, et al. 1997.

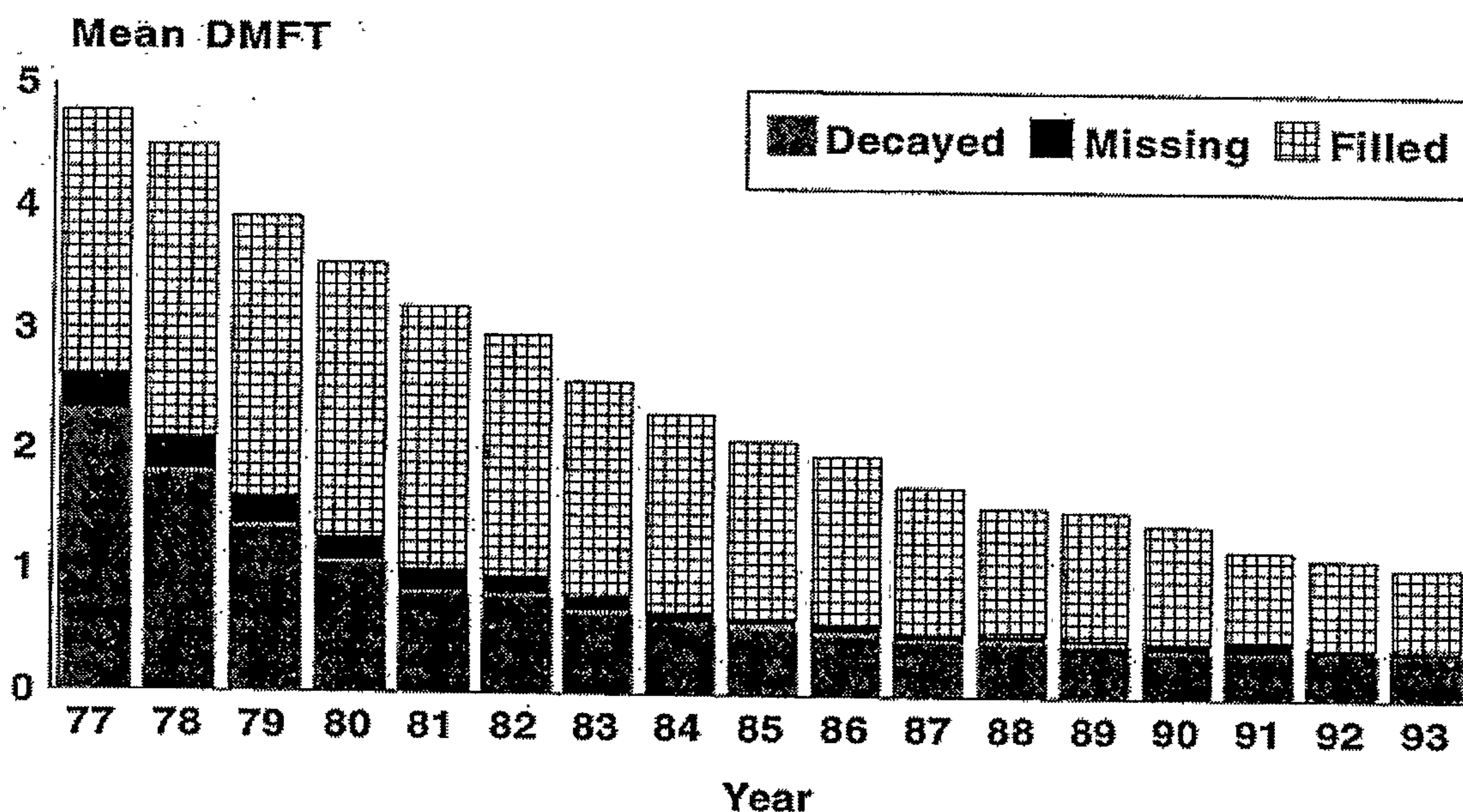


**Figure 1.3:** Mean DMFT components in 12 year old children in Australia from 1977 to 1993. Figure reproduced from study by *Davies, Spencer, et al. 1997.*

Figure 1.4 shows frequency distribution of dft and dmft for 6-year old children for the years 1977, 1985 and 1993. There has been little change over time in the shape of the distribution apart from an increase in the percent with a zero dmft from 33.1% in 1977 to 53.2% in 1993. However, the elevated levels of primary caries experience relative to current levels of caries experience in the permanent dentition, and the shape of the disease distribution indicate a substantial burden of disease within the community. For instance, 21% of 6-year olds had a dmft of 4 or more in 1993, and 35% had a dmft of 2 or more (Davies et al. 1997).

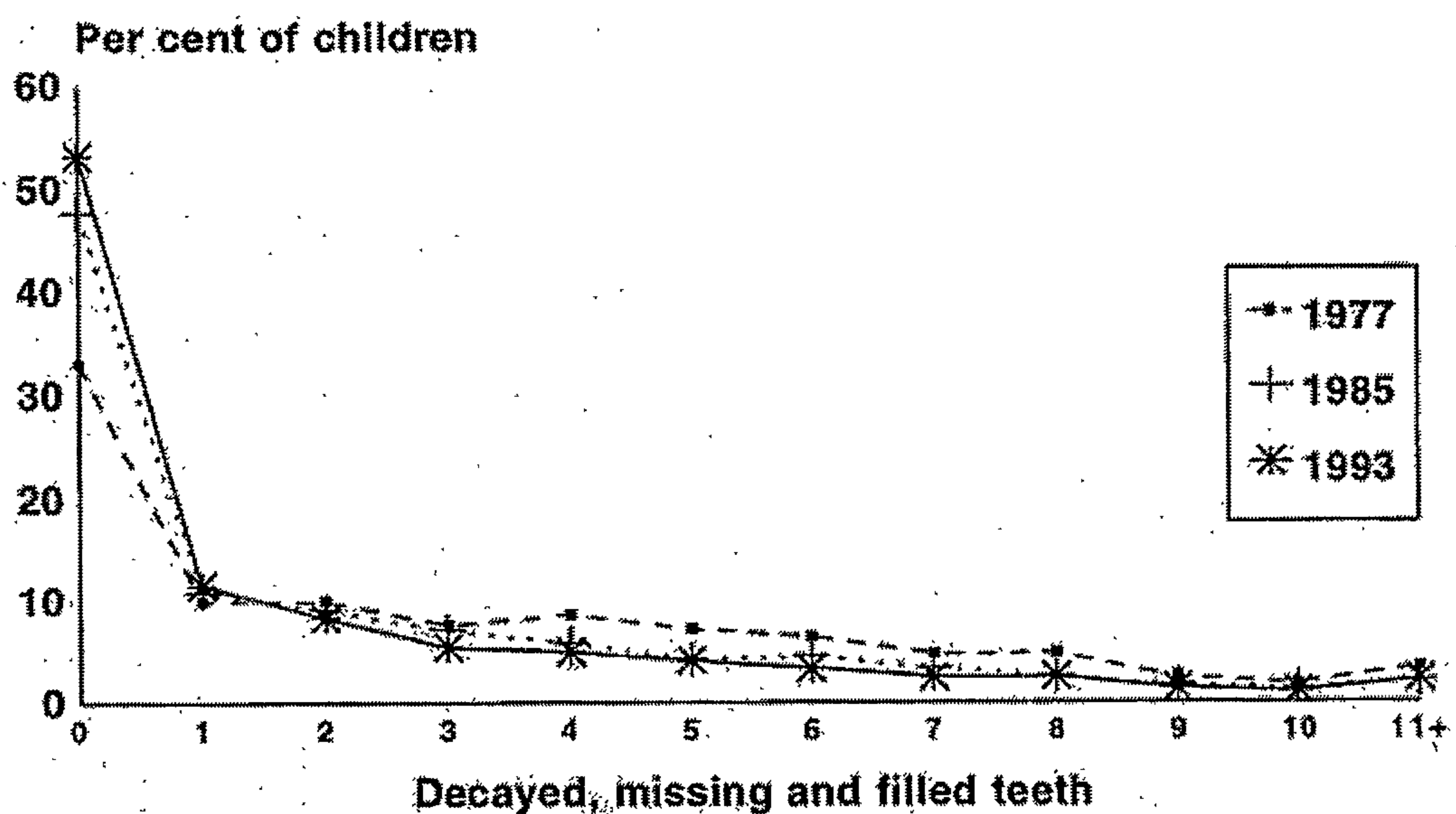


**Figure 1.4:** Distribution of dmft for 6 year old children in 1977, 1985, and 1993. Note dft for 1977 and 1985, dmft for 1993. Figure reproduced from study by *Davies, Spencer, et al. 1997*.

The pattern of change in the distribution of disease from 1977 to 1993 was different in the permanent dentition of 12-year old children. Figure 1.5 shows the frequency distributions for DMFT scores of 12-year olds for the years 1977, 1985 and 1993. In 1977 only 10.5% of children had no caries experience in their permanent teeth, with the most common score being a DMFT = 4. By 1985, the distribution was bimodal with the most common DMFT score of zero in 34.6% of 12-year olds, and a second peak at DMFT of 4 in 15.4% of children. 1993 had increasing numbers of caries free 12-year olds (55.8%), with a small minority of children showing high levels of disease. In this respect, 65.1% of 12-year olds had a DMFT of four or more in 1977, this percentage decreasing to 27.7% in 1985 and 11.6% in 1993 (Davies et al. 1997).

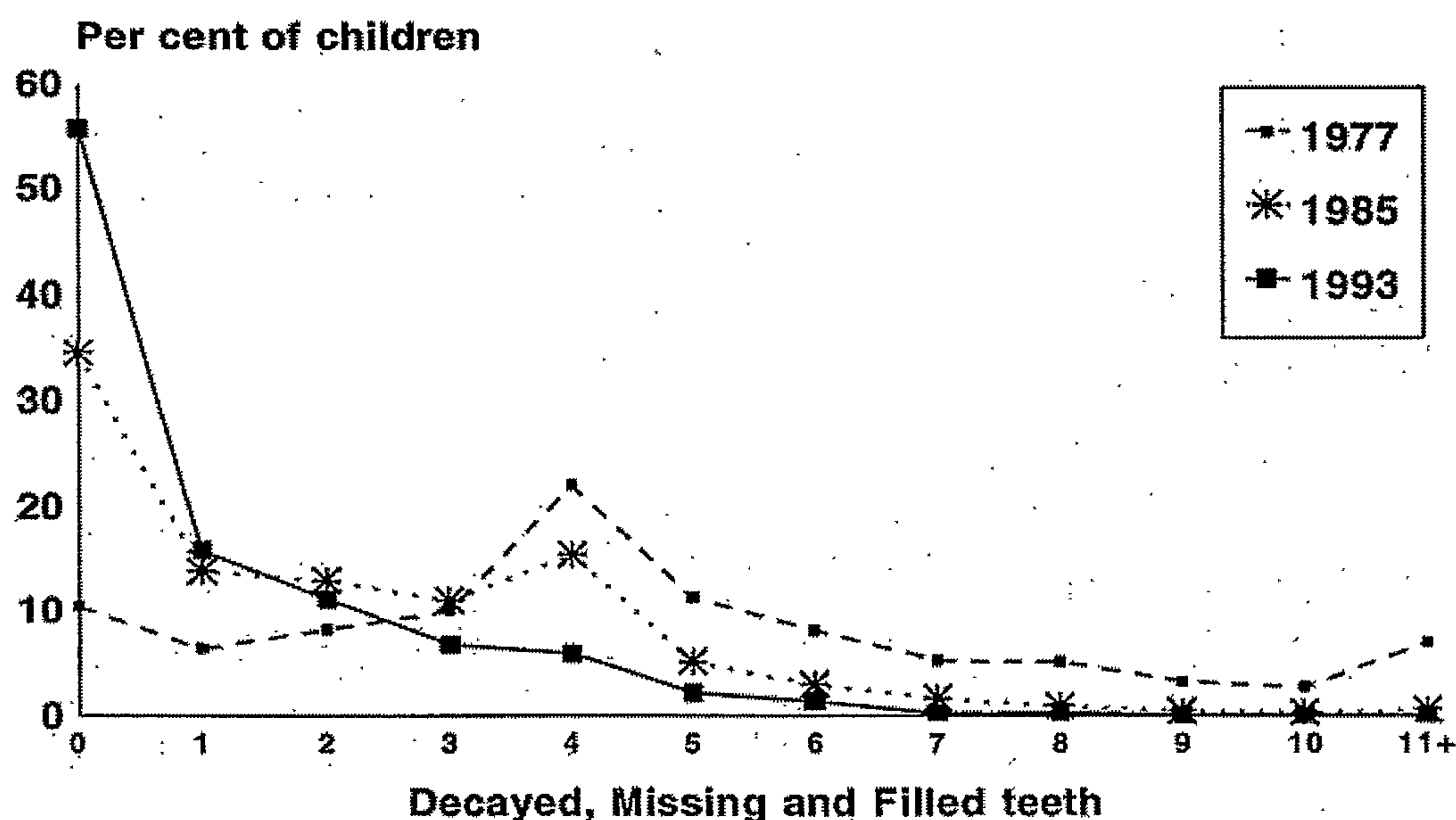


**Figure 1.5:** Distribution of DMFT for 12 year old children in 1977, 1985, and 1993.

Figure reproduced from study by *Davies, Spencer, et al. 1997.*

The substantial reduction of caries prevalence in school children in Australia from 1977 to 1993 represents a significant achievement in dental health within Australia. The apparent step up in the caries experience in 1989 reflected a change in the survey methods, particularly sampling strategies and, to a minor extent, the addition of missing teeth in the index. There is an indication that caries experience in the primary dentition for 6-year olds has plateaued as observed in other countries (Downer, 1992; Rugg-Gunn et al. 1988).

Data for the primary dentition presents a less favourable profile of caries experience than for the permanent dentition, with relatively stable disease patterns and a comparatively high proportion of the dmft index being made up of the untreated decay component of the dmft index. Despite the improvements in the ratio of decayed to filled teeth, young children still enter school with a high level of untreated decay. This result highlights a priority for both preventive and therapeutic care at an earlier age than routinely provided by school-age based dental care programmes. Furthermore, this would suggest that there is a need for targeting interventions and services at the minority of children who still have substantial caries experience (Davies et al. 1997).

### ***Nursing Caries***

Nursing caries is a specific form of rampant caries in the primary dentition of infants and young children. Typically, the condition is found in an infant or toddler who frequently falls to sleep sucking a nursing bottle filled with sweetened fluids (including milk), a pacifier dipped in sweetener, or who has a prolonged demand breast feeding habit. In most cases, nursing caries is a form of overindulgence rather than neglect. Frequent intake, prolonged oral clearance, and the lowered circadian flow of saliva at night all appear critical to the development of nursing caries (Johnston and Brearley Messer, 1994; Ripa, 1988; Davenport, 1990).

Determining the true prevalence of nursing caries is difficult since most children affected are of pre-school age and not accessible for examination (Ripa, 1988; Davenport, 1990). Furthermore, data collected may be from biased samples, for instance, children whose parents are aware of an existing dental problem are more likely to present for examination (Ripa, 1988; Kamp, 1991), or different diagnostic criteria may affect the assessment of prevalence. The reported prevalence of nursing caries in western countries is less than 5 per cent (Ripa, 1988; Davenport, 1990; Kamp, 1991). Comparatively, Australian studies have reported prevalences ranging from 2.6% to 6.4% (Calache and Wright, 1987; Brown et al. 1985; Wyne et al. 1991). In summary, determining the number of children affected by nursing caries is extremely useful as approximately two thirds of the children seen in this study were of preschool age. These are the typical children who may require general anaesthesia.

### ***Water Fluoridation in Australia***

Since the commencement of water fluoridation in Australian State capital cities in 1964 and The Tasmanian Royal Commission in 1968 (Crisp, 1968), water fluoridation was promoted as the cornerstone of public health policy for the prevention of dental caries in Australia. However, in recent years questions have been raised about the effectiveness of water fluoridation. In particular, the need for this public health measure when children's caries levels are at historically low levels, and other fluoride vehicles (particularly toothpaste) are widely available (Diesendorf, 1986; Colquhoun, 1990; Diesendorf et al. 1997).

In Australia today nearly two-thirds of the population resides in an area with adjusted fluoride levels in the water supply (Commonwealth Department of Health, 1984). Between 1964 and 1977, seven of the eight capital cities implemented fluoridation of public water supplies. Over the past 50 years, since the first fluoridation project in North America, there has been an accumulation of epidemiological evidence that supports the benefit of water

fluoridation. In Australia, the Tamworth study, which began in 1963 with a pre-fluoridation survey and carried through to 1988, reported on the decrease in caries in 6- and 12-year old residents in the fluoridated city (Barnard, 1989; Barnard, 1990). Several other pre-1980 studies have also firmly supported the benefits of fluoridation in Australia (Videroni et al. 1976; Carr, 1972; Carr, 1976). Current research has shown water fluoridation to be associated with reduced caries experience in Australian children (Spencer et al. 1996). Since the NHMRC review of water fluoridation in 1991, three Australian studies have examined the association between caries experience and exposure to water fluoridation: Western Australian children (Riordan, 1991); New South Wales children (Patterson and Weidenhofer, 1993); and, South Australian and Queensland children (Slade et al. 1995; Slade et al. 1996a; Slade et al. 1996b).

The number of vehicles through which exposure to fluorides may occur has increased in recent decades. In Australia the main fluoride vehicles are water fluoridation, toothpaste with fluoride and fluoride supplements. The changing pattern of fluoride exposure has accentuated the need to determine the relative benefits of fluoride from water versus other contemporary sources. Over 95 per cent of toothpaste marketed contains fluoride. Analysis of the interaction of brushing frequency with lifetime exposure to water fluoridation has indicated that even among children brushing regularly there is a 24% advantage of lifetime exposure to water fluoridation over those with no exposure. This finding indicates that: water fluoridation has an additive effect with fluorides from other sources in the prevention of dental caries in children; and, neither toothbrushing with a fluoride-containing toothpaste nor water fluoridation make the other fluoride vehicle redundant in the prevention of caries (Davies, 1993).

In summary, water fluoridation has had a significant effect in caries reduction in children since its introduction. However, the multicultural nature of the child population in Sydney,

and the fact that many of these children were born overseas means that not all children benefit from water fluoridation. This observation supports the fact that only a small proportion of children are responsible for most of the decay experienced by Australian children (Davies et al. 1997; Widmer and Mekertichian, 1996).

### ***Providers of Child Dental Care***

The delivery of dental care to children in Australia is through both public and private sectors. Many children of school age have access to free dental care either through dental school clinics, dental therapist colleges and major teaching dental hospitals. The more recent introduction of a screening program in NSW called "Save Our Kids Smiles" or SOKS for short has altered the number of children that receive a dental examination. In NSW dental care for children in private practice is mainly provided by general dentists and only a small number are seen by paediatric dentists (only three registered specialists in the private sector in NSW). It is therefore the objective of this section to briefly describe who provides dental care for children in NSW and specifically for the Sydney metropolitan area.

It is difficult to determine with accuracy the proportion of children seen by different dental personnel in Australia. Previous national surveys have estimated the place of the last dental consultation by children between the ages of 2 to 14 years for a 12 month period. For the year ending in April 1995, a total of 574,800 children (out of a possible 1,120,700 children) consulted a dental professional in NSW. Of these, 58% were seen in private surgeries; 32% were seen by the School Dental Service; 5% were seen at a community dental clinic; 4% were seen in a hospital and 0.5% by other (Szuster and Spencer, 1997).

### **SOKS Program**

While water fluoridation and the use of fluoride toothpaste have led to a dramatic improvement in the dental health of the general population there is still a large number of

adults and children who experience unacceptable amounts of tooth decay and gum disease. These are historically those who do not access regular dental care. To improve the dental health of children, the NSW Health Department joined forces with the Department of School Education, the Catholic School Commission and private dental practitioners to launch the Save Our Kids Smiles (S.O.K.S.) program. This program was previously referred to as the Dental Assessment and Prioritisation Program (D.A.P.P.). This particular program was trialed in some centres of NSW and the improvement in oral health in these communities was considerable. It was found that particular attention needed to be paid to children in lower socio-economic groups, Aboriginal children and children from non-English speaking backgrounds. The program was aimed to children in Kindergarten and grades 2, 4, 6, and 8. The emphasis of the S.O.K.S. program is on prevention and it does not give each child a full dental examination. It aims to give them a caries-risk assessment and should a child require treatment parents were actively encouraged to visit their family dentist (Dental Health Branch, 1996a).

The SOKS program began in NSW schools at the beginning of 1996. Prior to its introduction only 26% of children aged between 5 and 14 years were treated in public dental clinics (and 74% were not seen; data from year 1993). Of these 26%, nearly two thirds had been seen by the service within the last 12 months, and only 39% were new to the service. This meant that those patients that sought treatment or those that were highly motivated were seen and treated. Those with low literacy skills, or language difficulties, or from low socio-economic backgrounds were rarely seen, despite being those with the largest amount of decay. Data from The National Oral Health Survey showed that 36% of children sought care in the private sector while 5% were using both the private and the public system. Furthermore, 43% of children had no access to dental care at all (Dental Health Branch, 1996b).

Initial results from the SOKS program found that 58% of children had no caries experience and 42% had some need of dental treatment (data for year 1996). Of those children that required treatment 4% were considered to be in need of immediate attention, and 32% had untreated disease or were considered to be at risk of further dental disease (NSW Dental Health Branch, 1997).

### **Private dentists involved in the treatment of children**

It is apparent from the figures given by the SOKS program that a significant proportion of children are seen in private practices by private dentists. The exact numbers are difficult to estimate but a study found that 335,300 children aged 2 to 14 (out of a total of 1.12 million children in NSW) attended a private dentist for the year ending in April 1995 (Szuster and Spencer, 1997). Unpublished data in NSW has shown that general dentists (ADA members) do not see a lot of children when compared to their overall patient load. In contrast, dentists that are members of the Australian and New Zealand Society of Paediatric Dentistry (ANZSPD) see significantly more children than their ADA counterparts (Kilpatrick et al. 1998).

### ***Services at Westmead Hospital***

Provision of dental treatment for children at The Westmead Dental Clinical School is mainly provided through the department of Paediatric Dentistry. Dental treatment has been free of charge to all children up to the age of 16 years since the opening of the hospital in 1983. However, due to cuts in funding by the federal government and the increased demand in recent years, this service has been restricted to children within the Western Health Area and to those requiring specialist care. The introduction of newer screening programs such as SOKS has further modified how patients access this hospital.

All new patients are assessed by general dentists or dental therapists within the hospital or by the School Dental Service. Most children are treated at the paediatric dentistry department, but a significant number is diverted to general dentists and therapists within other departments, or to undergraduate dental students of The University of Sydney. These are children that require straight forward dental needs and do not present management problems during the delivery of dental care.

### Paediatric Dentistry Unit

The department of Paediatric Dentistry is made up by two senior consultants in Paediatric Dentistry, one senior lecturer, several registrars at different levels of training in the discipline, visiting paediatric dentists and resident dentists working a certain number of hours per week. The main purpose of this department is to provide specialist paediatric dental care to children with special needs. This usually involves treatment of children who are medically compromised, children that have suffered dento-alveolar trauma, children with management difficulties or those with high levels of caries, and children that require surgical treatment due to soft tissue lesions, trauma or orthodontic related surgery. A significant amount of interceptive orthodontic treatment is also carried out as well as routine orthodontic work, mainly through the department of Orthodontics. This wide variety of services requires the constant involvement of specialists in different disciplines of Dentistry. This multi-disciplinary approach assures adequate planning and delivery of dental treatment.

In order to deliver such a wide scope of dental treatment to children, several management techniques are used. These range from simple behavioural methods to different levels of sedation. The most common form of sedation used in the unit is relative analgesia or nitrous oxide sedation. Other forms of sedation include oral sedation and IV sedation but these are used less regularly. Day-stay General anaesthesia is provided on a regular basis and approximately 18-22 patients are seen every week for the delivery of dental treatment.

## Description of GA process

The provision of general anaesthesia (GA) in paediatric dentistry is considered a specialised service and all patients follow a similar protocol which involves several steps. First, all referrals are booked through a consultant's clinic to assess the need for GA. However, a significant number of patients requiring this service access the hospital through the emergency department. The indications for GA have already been discussed and this section will describe the process of having a GA at this hospital.

### **Initial consultation**

All patients undergoing GA have an initial consultation at which time a thorough medical and dental history is taken. This may involve liaising with the referring dentist or medical practitioner in order to obtain a more detailed history. Patients that are significantly medically compromised may require further tests or investigations to ascertain their fitness for GA. This usually involves a pre-anaesthetic assessment for further evaluation. A family and social history are also important as it provides other relevant information, such as history of complications to anaesthesia in the family, place of residence, issues of guardianship and consent, parental expectations, etc. A thorough clinical examination, dental charting and provisional treatment plan then follow, and these are discussed with the parent/caretaker. A relevant radiographic examination is carried out at this time, and whenever possible an OPG is requested for children having a general anaesthetic.

Other issues related to GA are also discussed at this appointment. The most important issue is appropriate and informed consent. This involves a detailed explanation of the procedure to be carried out and any possible complications that may arise. The consent form is signed by the parent or legal guardian and witnessed by the dentist. All patients are expected to be taken home by private transport whenever possible. If no appropriate arrangements can be made, the GA time is rescheduled. Preferably, all children should be accompanied by two

adults to facilitate the trip back home, and no other children should be present to ensure full attention is given to the child undergoing the GA.

Fasting is required for all patients undergoing general anaesthesia. Generally all children should be fasted 4 hours for clear fluids and 6 hours for solids or milk. In practical terms, this means that all children having a morning GA session should fast from the night before. In order to expedite the process, younger children are placed first in the list as they tend to dehydrate and become more irritable faster. Children with significant medical histories are also booked earlier to allow a more prolonged recovery if necessary.

### **Admission to day-stay unit**

All child patients admitted to hospital are booked at one of two starting times: 7 am or 11 am. Admission is carried out first by reception staff and then by nursing staff from Dental Theatres. All children are examined for fitness for GA by medical nurses and this is followed by an anaesthetist assessment. At this time the presence of an interpreter may be required to assist with any questions by medical and dental personnel. Then the parents are requested to change their child into a hospital gown and they are assigned a bed in the recovery unit. The need for premedication is determined and this is usually in the form of a combination of oral paracetamol and midazolam. If intravenous induction is being considered, a topical anaesthetic cream (e. g. EMLA<sup>®</sup> patch) is placed on the dorsum of the hand. One parent is allowed to accompany the child during this process. Once the admission is complete, the dentist carrying the procedure on the day discusses once more the procedure with the parent or guardian. This may be altered on the day as the child may have developed other dental problems, especially if patients have waited several months in the waiting list.

### **Induction and maintenance of GA**

In order to minimise separation anxiety parents are allowed to accompany their children up to the time of induction of anaesthesia. The mode of induction usually depends on the

anaesthetist, although some children/parents may have a specific preference. Inhalational induction is probably used more frequently in children, and a mixture of sevoflurane with nitrous oxide/oxygen is usually given. Other children may undergo intravenous induction with thiopentone or with propofol (older children). Induction and preparation of the patient for the operation is carried out in a preanaesthetic room directly attached to the operating theatre. An intravenous line is obtained via a cannula as soon as induction is achieved. Nasal intubation is carried routinely to facilitate access to the oral cavity. This is achieved by the use of nasal Rae tubes which are preformed and come in different sizes. These tubes allow all anaesthetic hoses to be directed away from the mouth and therefore facilitate access. The need for muscle relaxants in children undergoing dental general anaesthesia varies, and this is subject to the anaesthetist preference.

All patients are classified according to the American Society of Anaesthetists classification (Owens et al. 1978), with most children being ASA I or II. A selected number of patients may be ASA III or E (see Appendix No. 1). Anaesthesia is maintained usually with a mixture of halothane and nitrous oxide/oxygen although other drugs are also used. Monitoring of the patients is in accordance with current guidelines for the provision of anaesthesia (see Appendix No. 5). Once the dental procedure is complete the patient is allowed to become conscious and regain his/her protective reflexes before extubation. Oxygen is delivered through a mask and the patient then transferred to the recovery unit where constant monitoring and recovery is carried out. Intravenous access is maintained open until the child has made a full recovery.

### **Recovery and discharge**

Once the child is in the recovery area and becomes more responsive, one of the parents is allowed to comfort the child. Recovery of most patients is approximately two hours and must comply with current guidelines before a patient can be discharged. They must be fully conscious and alert before discharge is considered. All children are offered jelly or an ice-

block in order to assess recovery and to encourage oral intake. Once the patient has made a full recovery, the cannula may be removed. Parent and child are then allowed to spend some time in a special parent/recovery area where children can watch TV and settle further. Nursing staff need to be satisfied with the child's progress before sending the child home. If there are any concerns the anaesthetist may at this time evaluate the child and decide on the child's readiness to be discharged.

All children undergoing GA are given a postoperative review appointment a week later. This is done to assess the work carried out and to assess the parents response to this modality of treatment. Furthermore, those children that presented with high levels of caries could be monitored more closely and kept in a recall system. However, due to the high demand and increasing waiting lists, this situation is currently under review due to resourcing constraints.

## **CHAPTER 2 . AIMS & OBJECTIVES**

### **Background to the study**

Providing dental treatment under general anaesthesia (GA) is costly in terms of staffing, equipment, time, morbidity and emotional stress. The provision of dental treatment under GA is a service that is often under threat when financial constraints take effect and pressure is often exerted to reduce its use. However the nature and amount of dental disease, much of which is preventable, makes the use of GA necessary. By identifying risk factors associated with its use, recommendations concerning appropriate targeting of dental education and resources can be made. At present little is known about this service in Australia, who access it and for what reasons, and finally what type of treatment is provided.

In New South Wales, Westmead Dental Clinical School is the main provider of specialist dental services and the only hospital that has access to regular paediatric dental general anaesthetic sessions. Therefore this center may be considered to be the largest provider of paediatric dental GAs. A review of the patterns of care and the characteristics of the patients managed at this center since its inception in the early 1980's can provide the basis for future resource planning.

### **Hypothesis**

It can be hypothesised that despite a decline in the prevalence of dental caries in the child population in NSW (and Australia), there has been an increase in demand for paediatric dental GA services. There have been changes to the characteristics of the population involved and the treatment needs of these patients. It has been suggested that more pre-school children from specific socio-economic groups are accessing the service now than in

1984. In addition it is likely that more complex restorative and surgical treatment is now provided as the service has expanded.

## **Aims**

1. To assess the demand for dental general anaesthesia at the Westmead Dental Clinical School, Sydney, Australia.
2. To evaluate the changing pattern of use of GA in children at this hospital over the past ten years.
3. To make recommendations for appropriate future resource planning.

## **Objectives**

1. To evaluate the use of day case anaesthetic services by paediatric dental patients over the past decade.

*Postulate:* The number of children receiving dental care under general anaesthesia has increased over the past 13 years.

2. To describe the characteristics of the child patients receiving dental care under GA.

*Postulate:* The demographic, socio-economic, and cultural characteristics of these patients have altered over the past 13 years.

3. To identify risk factors associated with children requiring dental care under GA.

*Postulate:* That young children from specific ethnic backgrounds make up an increasing proportion of patients requiring extensive dental treatment under GA.

4. To evaluate the changes in the pattern of dental care provided under GA.

*Postulate:* The treatment need of the children receiving dental care under GA over the past 12 years has changed with increasingly complex restorative work being required.

5. To monitor the waiting list time for children using this service.

*Postulate:* That the demand for dental GA has been met by the service commitment as assessed in terms of the length of the waiting list.

## CHAPTER 3 . MATERIAL AND METHODS

A retrospective study of the use of general anaesthesia in children was carried out at the Westmead Dental Clinical School (WDCS), Westmead Hospital, Sydney, Australia. WDCS has provided general anaesthesia for this purpose since 1983, but its use in children has not been evaluated during this time. This study included only cases treated as day-stay admissions, and no attempt was made to record cases treated as overnight admissions (inpatients or emergencies).

Ethical approval was sought from the Western Sydney Health Authority in order to obtain information from patient's records. Data from the central hospital admissions database (PMIATS: Patient Master Index, Admissions Transfer Separation) was downloaded and converted to ASCII text format. Printouts of all GA cases since 1983 to date were obtained.

The following fields were included in these printouts:

- Dental Record Number (DRN)
- Admission date
- Separation date (discharge date)
- Sex
- Date of birth
- Address

### Methods

The total number of GA procedures carried out for each year was recorded since 1983. This was done in order to correlate the number of general anaesthetics with the number of sessions and operators available for each calendar year. Therefore, data was also collected regarding the number of sessions per week and the number of operators for each year. A

“session” is defined as four working hours or half a day (morning or afternoon session). The operators involved were all paediatric dentists, either registered specialists or postgraduates undergoing training.

Information from years 1984 and 1996 was recorded. The reason for this decision was that 1984 was the first year in which GA was provided on a regular basis, whilst 1996 provided information of current utilisation of GA services. In this way comparisons and conclusions could be drawn in order to assess changes during the two periods. The computer printouts were carefully screened for the two years selected, noting that some records appeared twice in the lists provided. The reason for this computer error could not be established. After this initial data was cleaned, a request for the patient’s notes was made.

On discussion with the hospital statistician a sample size of 209 (all records available) in 1984 and 213 in 1996 were chosen. By using the inbuilt Statistical Analysis System (SAS), a random subset of patient records was selected for the year 1996. In this way a computer printout was obtained with a random selection of the dental record numbers of the chosen files for the year 1996.

Notes for the year 1984 were more difficult to obtain, as many of these patients had not attended this hospital for some years. The bulk of these records were collected from secondary storage rooms, as they were not currently in use. Dental Records department at WDCS coordinated this task. Thirteen records could not be found or had been destroyed. All records retrieved for this year were:

- admissions under Dr Richard Widmer (the only paediatric dentist at the time with admission rights)
- day-stay cases
- patients assessed in the Department of Paediatric Dentistry
- children between the ages of 0 to 16 years of age

The aim of the study was to evaluate the use of services in the department of Paediatric Dentistry, therefore children seen in the Oral-Maxillofacial Unit and treated under GA were not included in this study. Two records of patients older than 16 years of age were found, but not included in this study. Records for the year 1996 were readily available, but had to be retrieved in smaller groups as they were currently in use by other clinicians.

In total, 189 records were used for the year 1984 and 213 for 1996. One person recorded all information. A personal computer with Windows® 95 and Microsoft® Access Database was used for this purpose. A special input sheet was designed (see Appendix No. 7) to expedite data entry and suit individual needs. The information recorded was subdivided into four major groups and details of this data are shown in Table 3.1.

| Patient details  | Demographic data       | Treatment provided  | Other data        |
|------------------|------------------------|---------------------|-------------------|
| Gender           | Suburb of residence    | Extractions         | Medical condition |
| DRN              | Assess./Treatment date | Primary dentition   | Follow up history |
| Date of birth    | Reason of referral     | Secondary dentition | Repeat GAs        |
| Ethnicity        | Source of referral     | Surgical procedures | Morbidity of GA   |
| Health insurance | Waiting time           |                     | Comments          |

**Table 3.1:** Data collected for assessment and evaluation of GA use in dentistry for children

## **Patient details**

### ***Gender***

The gender of all patients was recorded in the database sheet, and these children were classified as male or female. A sex ratio would then be calculated to work out the proportion of males to females. This information was gathered in order to make comparisons within our patient population and other studies in the literature.

### ***Dental Record Number (DRN)***

The DRN was the most useful way of identifying a particular record and maintaining confidentiality for individual patients. It also provided a way of sorting data, and the quickest way of finding a specific set of patient records.

### ***Age***

Age was considered an important factor when discussing dental caries and the use of GA in children. This parameter was recorded as date of birth, and age in years at the time of treatment, that is exact age at the GA procedure.

### ***Ethnicity***

Ethnicity was recorded with the idea of identifying any ethnic groups that may be more at risk of requiring treatment under GA. However reliable assessment of ethnicity was difficult as patient notes did not always document this accurately. Factors such as country of birth and language spoken at home were taken into account when assigning ethnicity. Due to the multicultural nature of the Sydney population, this parameter was considered of significant importance. Ethnicity was divided into:

- Anglo-Saxon
- Asian

- Middle-Eastern
- Aboriginals
- Other

It is believed that these subgroups made the most relevant ethnic groups when considering GA in children at this hospital. This is based on demographic data from the Australian Bureau of Statistics (ABS), as no previous studies of this nature have been performed at Westmead Hospital.

### ***Health insurance***

Health insurance was recorded, as it is important to determine the proportion of patients treated through Medicare (public health system) as opposed to those with private insurance. The provision of a regular private GA list became available only in the last two years (1997 and 1998) and therefore did not affect results of this investigation. However, determining the number of patients with private cover allows us to estimate the proportion of these patients and therefore be able to make recommendations.

## **Demographic data**

### ***Suburb of residence***

The place of residence was recorded for all patients. Westmead Hospital has provided dental GA services for children from most areas of Sydney and some other NSW cities in the last decade. The postcode of each patient was recorded and then patient distribution by area was noted for the years 1984 and 1996. These were divided into health areas as specified by the NSW Department of Health:

- Central Sydney
- Northern Sydney

- Southeastern Sydney
- Southwestern Sydney
- Wentworth
- Western Sydney (Westmead Hospital is located in this area)
- Other

### ***Assessment and treatment dates***

The assessment date refers to the day when the initial consultation was carried out. These were patients either referred from within the hospital, from another source outside the hospital (private or public) or an emergency/self referred patient. The treatment date refers to the actual day when the general anaesthetic is carried out. All cases included in this study were day-stay procedures. Patients are placed in either a morning or afternoon list, with admission times to the hospital at either 7 am or 11 am respectively.

### ***Reason for referral***

The reason for referral is one of the main aspects under investigation in this study. Patients were classified as caries, trauma, dental anomaly, or other. It was felt that these were the main referral reasons for treating child patients under general anaesthesia. It is important to determine why children require these services, and to also compare findings with similar studies in the literature.

### ***Source of referral***

The referral source indicates how a particular child patient requiring general anaesthesia came into the department of Paediatric Dentistry. Several sources of referral were noted, and these were classified as:

- General dentists
- Specialist dentists

- School dental service
- Doctors
- Self/emergency patients
- Other

General and specialist dentists included those practitioners in the private sector that have referred patients to this hospital. These dentists usually send a referral letter explaining a particular concern or inability to carry out treatment for whatever reason. The School Dental Service (including both therapists and dentists) refers patients in several ways. Patients are referred either from well established School Dental Service institutions around NSW, or through visits to school grounds to assess children's dental status. The recently introduced program "Save our Kids Smiles" or "SOKS" which started in early 1996, has broadened the number of children assessed per year, and has also affected the referral pattern to this hospital. Medical staff, either general practitioners or specialists refer patients to the hospital from either the private or public sector. This is also considered a proper referral channel as all patients bring a referral letter when first assessed.

Self-referred patients included patients seeking dental care on their own accord, but not necessarily in pain or discomfort. Emergency patients refer to those seeking relief of pain, treatment for trauma and/or odontogenic infections. These particular patients have not sought dental treatment anywhere else, and they present to the hospital as their first place of choice. Westmead Hospital is considered to be a specialist referral centre not a primary healthcare provider and many people are thought to access its services inappropriately. Patients categorised as "Other" included patients referred to the unit by other clinicians within the hospital, as well as patients currently treated within the Paediatric Dentistry unit that after having some treatment initially, were found to be unmanageable.

## ***Waiting time***

The waiting time refers to the time period between the assessment date and the treatment date, that is the time of the general anaesthetic procedure. This is a useful parameter when assessing demand of services, as it gives an indication of how long patients wait before they receive treatment under general anaesthesia. It also allows a comparison in demand for services with other institutions that provide similar services. Waiting times were recorded in "days" and an average waiting period was calculated for the years 1984 and 1996.

## **Treatment provided**

### ***Extractions***

The number of extractions in the primary and secondary dentitions was recorded in order to compare both periods examined. The database recorded the number of extractions carried out per patient in each dentition. No attempt was made to record the actual teeth (tooth number) being extracted. This figure gives an indication of severity of disease and facilitates comparison with other studies when referring to this treatment modality.

### ***Primary and Secondary dentition***

Treatment was recorded for the primary and permanent dentition. The access database form made provision for recording the type and number of restorations (e.g. amalgam, composite resin, glass ionomer, preventive resin restoration, fissure sealants, stainless-steel crowns), the number of extracted teeth, need for pulp therapy or endodontic treatment, and other details. A ratio of the number of treated, extracted, and restored teeth per child in both dentitions was made. This was considered useful as comparisons could be made with the general treatment needs (dmft/DMFT) of the child population in Australia overall, and the treatment needs of children requiring GA at this hospital.