Risk Factors for

Repeat Dental General Anaesthesia

By

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I confirm that the work submitted is my own and that appropriate credit has been given where reference has been made to the work of others.

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Abstract

Background: Dental disease in children remains a significant cause of morbidity in the UK. In 2013-2014, more than 46,000 children were admitted to hospital for dental treatment under general anaesthetic. Whilst Dental General Anaesthesia (DGA) is a valid treatment option for some children, it is not without risk or significant resource. It is therefore important to establish risk factors that may make a repeat dental general anaesthetic more likely, in order to reduce this risk in future.

Aims: There were two parts of this study with individual aims. 1) Epidemiology study: to determine the prevalence of repeat dental general anaesthesia in children across North Yorkshire from 2002 to 2018. 2) Case Control study: to examine characteristics that are more commonly found in children receiving more than one dental general anaesthetic. These include patient demographics, medical and social history, pre-operative radiographs, and the treatment provided.

Methods: Electronic patient records from North Yorkshire Salaried Dental Services were searched for all patients under the age of 18 whom received DGA between January 2002 and May 2018. This included patients who received repeat DGA episodes. Records were examined to ascertain patient characteristics. These fell into three broad categories, patient demographics (such as age and gender), patient history (such as acute symptoms and medical history) and treatment provided (such as radiographic assessment and number of teeth extracted). For the epidemiology study, all children who received more than one DGA were included. For the Case Control study, all children who received more than one DGA (study group) were included and compared to a control group of children who received a single DGA.

Results: There were 6012 DGA episodes in North Yorkshire over the 16-year time period. 5427 patients received a single DGA. 248 patients received 2 DGAs, 20 patients received 3 DGAs, 6 patients received 4 DGAs and 1 patient received 5 DGAs. There was a total of 275 repeat DGA episodes. Repeat DGA prevalence was 4.8%, with an average interval of 3 years 5 months between DGAs. Age, number of restorations, radiographic assessment, and planned follow-up at the first DGA episode were all associated with increased likelihood of repeat DGA, as was the presence of a neurological disability.

Conclusions: Specific risk factors for repeat DGA have been identified in this population. These risk factors should be taken into consideration when providing routine dental care, oral health advice, and when planning dental treatment under general anaesthetic.

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1 Literature Review

1.1 Introduction

Dental disease remains a significant cause of morbidity in children. For some children, the only way to effectively treat dental disease is with General Anaesthesia, also known as a Dental General Anaesthetic (DGA). In 2019-2020, more than 55,000 patients between the ages of 0-19 were admitted to hospital in the UK for dental treatment under general anaesthetic. Of these, at least 32,921 were to extract carious teeth in children under the age of 14 (Gov.uk, 2022).

Although DGA is a valid treatment option for many children, the majority of DGAs are to treat dental caries (Gov.uk, 2022). Dental caries is largely a preventable disease (Rugg-Gunn, 2013). Therefore, the current level of DGAs performed each year in the UK, to treat a potentially preventable disease, is disconcerting. Many of these children suffer whilst waiting for DGA treatment, with pain, infection, sleepless nights and missed school days (Goodwin et al, 2015). Furthermore, some children require multiple DGAs in childhood to treat the same preventable cause.

The practice of DGA in the UK has changed significantly in recent decades. The Poswillo report, published in 1990, recommended that DGA should be avoided where possible (Poswillo, 1990). This was further supported by several guidelines that suggested DGA should only be undertaken when absolutely necessary, and more recently, only within a hospital setting (Pike, 2000).

The aim of this study was twofold - to identify characteristics of patients who received multiple DGAs in across a 16-year time period, and to compare these characteristics to patients who received a single DGA in the same time period. These included

demographics, medical and social history, previous and current treatment, follow-up care, preventative advice, and attendance rates.

1.2 Definition and Nomenclature

In 2000, the Department of Health defined a General Anaesthetic as “any technique using equipment or drugs which produces a loss of consciousness in specific situations associated with medical or surgical interventions” (RCOA, 2022). It is important to note that this is different to other medical interventions such as conscious sedation, in which consciousness in maintained. This definition of General Anaesthesia is established and used consistently in current literature (RCS England, 2008).

When referring to Dental General Anaesthesia, the Dental General Anaesthetic episode is often referred to as DGA. When referring to multiple or repeat dental general anaesthetic, the first DGA procedure is often referred to as DGA1, and the subsequent episodes DGA2, DGA3 and so on. This paper will use these definitions when referring to DGA and subsequent DGA episodes.

The definition of ‘repeat’ DGA is not clear. Some studies consider the DGA a ‘repeat’ if it occurred within a 2-year period following DGA1 (Kirby et al, 2020). Other studies consider a repeat DGA if the child has had more than one DGA in their lifetime, regardless of the time between DGAs (Almeida et al, 2000). Furthermore, some studies imply that repeat DGAs are undesirable, unnecessary, or avoidable. However, it is accepted that some patients will require multiple DGAs throughout childhood and possibly adulthood, due to factors such as medical issues or dental anomalies.

It is therefore difficult to truly define a ‘repeat’ DGA within a set time frame and to assume it is always avoidable. For this reason, DGA will be used as a generic term to describe Dental General Anaesthetic episodes. DGA1, DGA2, DGA3, DGA4 and DGA5

will be used when referring to individual successive episodes of DGA. Repeat DGA will be used when a patient has received more than one DGA.

1.3 History of General Anaesthesia in Dentistry

1.3.1 Introduction of General Anaesthesia in Dentistry

The first procedure performed under general anaesthetic was a dental extraction in 1844. The technique of nitrous oxide induced anaesthesia was discovered by a dentist, Dr Horace Wells, at a travelling circus. He first used nitrous oxide to successfully extract one of his own teeth, performed by his apprentice. Following this, he attempted to demonstrate his technique to dental students at Harvard University. However, his subject cried out during the extraction, and he was deemed a failure (Landes, 2002).

Shortly after, one of his students, William Morton, used ether to successfully facilitate a dental extraction (Laird, 1990). This discovery was the start of pain management in dentistry, and a pivotal moment in dental history.

1.3.2 History of General Anaesthesia Use in Dentistry in the UK

In the early days of dental surgery in the UK, local anaesthesia was not widely available. Therefore, dentists routinely used general anaesthesia to provide pain free treatment for their patients (Landes, 2002). However, safety measures and resuscitation training were limited, leading to several potentially avoidable deaths. Between 1952 and 1999, more than 11 million DGAs were performed in dental surgeries and hospitals. 307 deaths were reported in this time (Roberts et al, 2020). Over the next four decades, several reports were published raising concerns over the safety of DGA in dental surgeries (The Spence Report, 1981; The Wylie Report, 1981; The Seward report, 1981; Coplans and Curson, 1981)

In 1990, Professor David Poswillo made recommendations for the safe provision of general anaesthesia in dentistry outside a hospital setting. Commonly referred to as The Poswillo report, his recommendations advised dental surgeries use the same safety standards as hospital theatres and avoid the use of general anaesthesia where possible (Poswillo, 1990).

However, recommendations were not always followed, and there were several more deaths resulting from DGA carried out in the dental surgery. More than 50% of deaths were children under 16 years of age (Coplans and Curson, 1982).

In 1995, the Clinical Standards Advisory Group reported that recommendations following the Poswillo report were either not being followed or had no effect on mortality. It found an average of two patients per year were still dying under DGA in the dental surgery (Seel, 1995). The General Dental Council (Poswillo, 1990) and the Royal College of Anaesthetists issued further guidance that general anaesthetics could only be carried out by anaesthetists or doctors working under a consultant anaesthetist (RCOA, 1990).

The practice of general anaesthesia in dental surgeries was banned in the UK in 2000, following publication of the report ‘A Conscious Decision’. This report recommended that DGA should only take place in a hospital setting after 31st December 2001 (Pike, 2000). Since then, there have been no reported deaths due to DGA recorded in the UK.

1.4 Guidelines for the Use of General Anaesthesia in Dentistry

The Guidelines for the Management of Children Referred for Dental Extractions Under General Anaesthesia published by the Association of Paediatric Anaesthetists (Adewale et al, 2011) were developed to create an evidence-based consensus on the most appropriate management pathway for children receiving DGA.

Key recommendations of this document included:

- DGA should only be performed when this is considered the most clinically appropriate method of management.
- The operating dentist should be a specialist in paediatric dentistry.
- The patient should receive a full pre-operative assessment including radiographs.
- Repeat DGA should be avoided and reduced.

The UK National Clinical Guidelines in Paediatric Dentistry: Guideline for General Anaesthesia in Paediatric Dentistry (Davies et al, 2008) states that there are only two reasons a child should receive a DGA – the child needs to be fully anaesthetised for them to accept the treatment, or for the surgeon to perform it. They state that carious asymptomatic teeth with no signs of sepsis rarely justify a DGA, as well orthodontic extractions and patient or parent preference.

In addition to guidelines on the safety and justification of DGA, further guidelines have been developed regarding the provision of paediatric dental services across the UK. In order to reduce the number of DGAs, subsequent DGAs and streamline the DGA service, the 2018 Commissioning Guide for Paediatric Dentistry made several recommendations (NHSE, 2018).

These include:

- General Dental Practitioners should discuss DGA with patients prior to referral
- The referring clinician should have attempted other forms of treatment including prevention advice, behaviour management and sedation where appropriate.
- Operative DGA treatment should be provided by a Level 2 or Level 3 dentist.
- Treatment planning for DGA should be completed by a specialist in paediatric dentistry.

The guide recommends an improved structure for the provision of paediatric dental care in the UK, with specific focus on DGA. Dentists with additional expertise or training in paediatric dentistry (sometimes known as level 2 dentists) should be able to perform extractions under GA. However, these dentists should still rely on the support of a specialist in paediatric dentistry when it comes to DGA treatment planning. Specialists and consultants in paediatric dentistry should be responsible for treatment planning, as well as the provision of DGA (NHSE, 2018).

1.5 Alternatives to General Anaesthesia

The Guidelines for the Management of Children Referred for Dental Extractions Under General Anaesthesia recommend DGA should be used as a last resort (Adewale et al, 2011). Other methods should be considered first, such as non-pharmacological and pharmacological options, prior to the use of DGA.

1.5.1 Behaviour Management

'Non-pharmacological management techniques' (FDS, 2002), published by the Royal College of Surgeons of England, details evidence-based behaviour management techniques. These can be used to manage children's worries and anxiety during dental treatment, with each method having specific applications and merits. With appropriate use of these techniques, the need for DGA may be reduced or prevented.

The use of these techniques has been found to reduce anxiety and facilitate the patients ability to accept treatment without additional pharmacological adjuncts (Foylan and Idehen, 2005). Even with pharmacological methods, these techniques can be used pre- or post-operatively and alongside the procedure to aid acceptability of treatment (AAPD, 2015).

1.5.2 Conscious Sedation

The Intercollegiate Advisory Committee for Conscious Sedation in Dentistry defines conscious sedation as ‘a technique in which the use of a drug or drugs produces a state of depression of the central nervous system enabling treatment to be carried out, but during which verbal contact with the patient is maintained throughout the period of sedation (RCS England, 2020). The drugs and techniques used to provide conscious sedation for dental treatment should carry a margin of safety wide enough to render loss of consciousness unlikely’.

There are distinct differences between this and the definition of GA. Specifically, due to the margin of safety that is maintained throughout the procedure, conscious sedation is deemed safe enough to be practicable in general dental practice (Standing Committee on Sedation for Dentistry, 2009). Despite the safety of nitrous oxide inhalation sedation, it is not widely used in general dental practices in the UK.

One of the aims of the Paediatric Dentistry Commissioning Guides is to encourage the training of dentists in inhalation sedation and increase its uptake as a realistic and safe alternative to DGA (NHS England, 2018).

1.6 Access to Paediatric Dental Services in the UK

1.6.1 Structure of Dental Services in the UK

The 2018 Commissioning Guide in Paediatric Dentistry recommends a working-framework for the delivery of paediatric dental care within the publicly funded National Health Service (NHS). However, due to organisational constraints, putting these recommendations into practice is not straightforward. Many services are still facing the same challenges such as workforce availability, budgets, waiting lists and regulatory barriers (NHS England, 2018).

1.6.2 Access to a Specialist in Paediatric Dentistry

Commissioners and managed clinical networks are responsible for service transformation but are financial constrained (Owen, 2021). Currently, there are not enough specialist paediatric dentists to fulfil recommendations outlined by the Commissioning Guide, even if budget were not a problem. 46% of postal areas in the UK have no specialists in paediatric dentistry. This is in stark contrast to the largely child-centred speciality of orthodontics, that reaches 98% of UK postal areas. There are roughly six orthodontists for every one paediatric dentist (Mills, 2020).

1.6.3 The Role of the General Dental Practitioner

The General Dental Practitioner plays a crucial role in managing the oral health needs of children. The Commissioning Guide outlines that children who can manage in mainstream primary care should be treated by their General Dental Practitioner (GDP) (NHS England, 2018). The GDP should also be responsible for looked after children's initial oral health assessment, where no additional needs are identified.

However, a number of studies have shown GDPs find children's dentistry challenging for a number of reasons. One study investigated GDPs views of providing dental treatment to children. The study demonstrated several perceived barriers to care, such as lack of specific training in paediatric dentistry and a practice environment that was targeted towards maximising profits. They reported time constraints as the biggest barrier to care (Timms et al, 2023).

1.7 Oral Health Surveys

1.7.1 Prevalence of Dental Disease

Oral health surveys provide valuable insights into the changes in dental health in the UK. The 2022 5-year-olds oral health survey found 23.7% of 5-year-olds had experience of

dentine decay, with an average of 3.5 decayed teeth (NDEP, 2023). There has been a decrease in the prevalence of dentine decay in 5-year-olds from 30.9% in 2008 to 23.3% in 2017. However, there has been no continuation of this improvement since 2017 (NDEP, 2023).

The child dental health survey is carried out every 10 years in the UK and is currently being updated. Data from 2013 reflect similar findings to the 2022 5-year-olds oral health survey in older children. In 2013, nearly half of 15-year-olds and 34% of 12-year-olds had decay in their permanent teeth (NHS England, 2013).

1.7.2 Burden of Dental Disease

The burden of dental decay remains unevenly distributed within the population. 5-year-old children living in the northwest of England are most likely to experience dentine decay overall (30.6%). However, the highest prevalence is found in small areas of London with up to half of children in these populations experiencing dentine decay (NDEP, 2023). On average, children in the most deprived areas were three times as likely to have decay (35.1%) as those in the least deprived areas (13.5%).

The 2013 child dental health survey found children who received free school meals, and those in lower income families, were more likely to have decayed teeth. 26% of these children in the 15-year-old group had severe or extensive tooth decay, compared to 12% of 15-year-olds who did not receive free school meals (NHS England, 2013).

1.7.3 Dental Disease and Ethnicity

The Child Dental Health Survey also found disparities in the prevalence of dental decay by ethnic group. White children were least likely to have visible decay (20.6%), compared to children from other (44.3%) and Asian (36.9%) ethnic groups. Children

from black (23.3%) and mixed (24.1%) ethnic groups had levels of tooth decay similar to the national average (Raja et al, 2016).

1.8 Complications Associated with General Anaesthesia

Non-preventable dental diagnoses, such as dental trauma, removal of supernumerary teeth, surgical removal/exposure of teeth and patient factors such as extreme dental anxiety, non-cooperation and medical issues are all justifiable reasons for a child to receive a DGA. None the less, DGA is not without risk and every effort should be made to avoid it where possible.

1.8.1 Pre-operative Complications

Pre-operative aspects of GA procedure can be daunting for a child. A recent study spoke to children about their DGA experiences. Several of the children reported negative physical and psychological outcomes before the DGA procedure. This included hunger due to pre-operative fasting, disturbed eating, feeling scared and worried in the lead up to the operation and pain from cannula insertion (Rodd et al, 2014).

One literature search found the pre-operative experience was very important to the child and their parents (Ramazani, 2016). Parents who were prepared with written instructions felt more comfortable with the procedure. They also found psychological techniques to be beneficial in helping patients relax prior to the procedures. These included simple explanations, game playing and distraction. Parental presence was also important.

Guidelines advise that children should ideally be given shortest waiting time possible for their DGA, to help minimize anxiety and acute dental issues (Adewale et al, 2011). However, with current demand, this is not feasible. The average wait for a routine DGA is over 6-months, with some children waiting over 2-years for treatment (Patel et al,

2023). Increasing waiting times, along with increased chance of recurrent pain is likely to add to dental anxiety and emergency visits to the dentist.

1.8.2 Operative Complications

Since 2000, there have been no deaths from DGA procedures (Roberts et al, 2020). This is largely due to the elimination of DGA procedures performed in dental surgeries (Poswillo, 1990). GA procedures are generally considered safe. The mortality rate is now estimated to be 1 death per 3.5 million DGAs (Roberts et al, 2020).

However, there are still serious risks associated with GA procedures and parents/patients should be made aware of them. Major complications include respiratory obstruction from inhalation of foreign material, airway obstruction due to the position of the throat pack or mouth-gag/prop, and from the presence of blood or debris. These may all result in aspiration pneumonia and hypoxic brain injury (RCOA, 2022). Injury to the neck may occur, as well as dislocation of the temporomandibular join (RCS England, 2023).

Thankfully, operative complications during DGA are rare. A study of 351 DGA procedures reported 4 (1.1%) procedures experienced operative complications. These were post-extubation croup, bronchospasm, and intraoperative bradycardia (Maes et al, 2022).

1.8.3 Post-operative Complications

Parents should be informed of common adverse effects that their child may experience. These include a sore throat, headache, nausea, sickness, dizziness, and the potential for an allergic reaction (Adewale et al, 2011). They should also be advised the child may need to spend some time off school, depending on their pain levels in the following days.

Common side effects reported by children following a DGA procedure include bleeding, pain and difficulty eating. In one study, 99% of children reported at least one complication in the days following their DGA. These ranged from inability to eat, bleeding, pain, drowsiness, vomiting, nausea, and fever (Farsi et al, 2009). Some children find the bleeding in particular very distressing, leading to panic and anxiety (Rodd et al, 2014).

In addition to short-term effects, the dental treatment they receive may have a long-term impact. For example, early extraction of primary teeth can lead to space loss within the permanent dentition, increasing the risk of crowding and need for further extractions and orthodontic treatment (Bhujel et al, 2016). Furthermore, the loss of permanent teeth can affect the child's occlusion, aesthetics, and psychological wellbeing, as well as increasing the need for future dental treatment (Bhujel et al, 2016).

These factors are also a burden on the parents and families of these children. Many parents have to take time off work and arrange alternative childcare and some also report feelings of guilt and distress following the DGA procedure (Knapp et al, 2016).

1.9 Cost of Dental General Anaesthesia

DGAs and repeat DGAs create a significant financial burden for the National Health Service. The Hospital Episode Statistics (HES) database records in-patient and day-case care from NHS hospitals across England (GOV.UK, 2022).

Using HES data, a simple estimate of the cost to the NHS can be determined. Tooth decay has always been, and still is, the most common reason children are admitted to hospital. From 2012 to 2016, paediatric dental extractions under general anaesthesia cost £129 million (PHE, 2016). Since then, the average annual cost of NHS DGAs is £30 million. There was a slight drop in 2020/2021 due to the drop in admissions consistent

with the SARS-CoV-2 outbreak. However, HES data from 2021/2022 shows the cost of paediatric DGAs was much higher than previous years, at £51 million, making up the shortfall from the previous year.

1.10 Rate of Repeat Dental General Anaesthesia

1.10.1 Rate of Repeat Dental General Anaesthesia Worldwide

Literature shows repeat DGA happens worldwide, with rates varying significantly. There are multiple challenges when it comes to correctly acquiring and analysing this information. To understand how many DGAs a child has had, a study would need to follow the patient for a significant number of years, until adulthood. Information may be unattainable due to patient dropout or lack of attendance. A study would also need to gather previous dental history, to correctly identify previous DGAs.

Due to the nature of the treatment involved, it is not possible to randomize or allocate patients to groups and therefore many studies involve retrospective data analysis. Most studies also span a fairly short period of time (Kirby et al, 2020), and it is not possible to say for certain whether children receiving a single DGA will go on to receive another. For this reason, analysing the average amount of time between repeat DGA episodes may be more beneficial.

In the USA, Almeida et al retrospectively analysed 4134 dental records over a two-year period. They found 42 children received a DGA, with 17% requiring a second DGA within 24 months (Almeida et al, 2000). A similar Boston study found out of 581 children receiving a DGA, 29 (4.9%) received a DGA2 within four years (Guidry et al, 2017). However, this study was limited to a 4-year period, so incidence of DGA2 may have been higher. Another US study, in Colorado, found 20% of patients receiving a DGA

prior to eruption of first permanent molars required a DGA2 within one year (Worthen and Mueller, 2000).

One Canadian study analysed records of 339 children who received more than one DGA over a 10-year period. They found 24% received a third DGA within that time frame, with an average interval of 42 months (D'Mello and Hallet, 2013). Another Canadian study reviewed the records of 300 fit and healthy children who received a DGA. 9 (4%) required DGA2 with an average 15.6 months between DGA1 and DGA2. Although the perceived repeat DGA rate was low, 83 patients did not return for follow up so the rate may have been higher. Furthermore, the study only spanned 4-years and no additional information was provided beyond that (Leagault et al, 1972).

D'Mello and Mallet (2013) found a repeat DGA rate of 4.3% in a group of 304 medically compromised children in Melbourne, Australia. All repeat DGAs occurred within an 18-month period. They repeated the study in a new group of 687 medically compromised children and found a similar repeat rate of 2.3% (16) over a 30-month period.

In Germany, Bucher et al (2016) examined records of 464 medically compromised children treated under GA. They found 50 (11%) received DGA2 and 7 (1.5%) received DGA3 over a nine-year period.

Overall, the repeat DGA rate outside of the UK is reported to be between 2% and 24%, with length of time between DGAs ranging from 15 to 42 months. Number of participants and length of studies varied, as did the patient demographic. Most studies were carried out in a set timeframe of less than four years, although two studies did analyse long term data spanning 10 and 9 years respectively (Schroth and Smith, 2007; Bucher et al, 2016) and looked at fit and well patients.

Repeat DGA prevalence and time-interval between DGAs findings from international and UK studies are summarised in table 1.1.

Table 1.1 Descriptive Table of Studies Demonstrating Repeat DGA Prevalence and Interval Between DGA

Author of Study	Length of study (years)	Patients (N)	Months Between DGAs (Mean)	Repeat rate
Jogezai et al. (2014)	5	191	24m	3.3%
Albadri et al. (2006)	5	33	28m	11%
Bucher et al. (2016)	9	50	28m	10.8%
Schroth & Smith (2007)	9	339	26m	24%
Kakaounaki et al. (2006)	6	52	22m	8.9%
Sheller et al. (2006)	1	23	25m	11.6%
Guidry at al. (2017)	4	29	34m	6.5%
Vertullo et al. (2021)	10	780	28m	10.8%
Almeida et al. (2000)	2	7	20m	17%
Legault et al. (1972)	4	9	16m	10.7
Kirby et al. (2020)	2	41	14m	1.1%

1.10.2 Rate of Repeat Dental General Anaesthesia in the UK

Jogezai et al examined dental records of children from three dental hospitals across two regions in the UK. 5749 children received a DGA, with 191 (3.3%) requiring a DGA2 and 9 (0.15%) requiring a DGA3 (Jogezai et al 2014). Similarly, Kirby et al examined records of patients at Sheffield Children's Hospital. 6467 DGAs took place over three years. 75 children (1.3%) had two more DGAs in this timeframe (Kirby et al, 2020).

Two studies identified previous DGA episodes. Albadri et al found within their cohort of 278 DGA patients, 33 (11.9%) had previously or subsequently received another DGA (Albadri et al, 2006). Landes and Bradnock found that 23% of the 309 children in their study requiring DGA had a previous DGA (Landes and Bradnock, 2006).

A retrospective longitudinal analysis carried out by Kakaounaki et al found of the 484 children who received a DGA, 10.7% received a DGA2 within a six-year period (Kakaounaki et al 2006). Savanheimo and Vehkalahti (2004) found a similar repeat rate of 11% within their 5-year retrospective study. This literature shows a repeat DGA rate between 1.3% and 23%, but again, studies varied in the length of data collection and study population.

1.10.3 Length of Time Between Dental General Anaesthetic Episodes

The length of time between DGA1 and DGA2 varies between studies. The length of each study varies significantly, and many studies do not report the length of time. For this reason, it is difficult to assess the true average length of time between repeat DGAs.

Jogezai et al (2014) found the average time between each DGA episode was between 12 and 36 months. These findings are similar to those reported by Harrison and Nutting, who found an average of 22 months between each DGA episode (Harrison and Nutting, 2000). Similar studies found averages of 22.5 months, 25 months, 27 months, and 42

months respectively (Savanheimo and Vehkalahti, 2014; Sheller et al, 2006; Albadri et al, 2006; Schroth and Smith, 2007).

Kirby et al (2020) examined records of patients at Sheffield Children's Hospital. 6467 DGAs took place over three years. 75 children had two more DGAs in this timeframe. 41 children received the first repeat DGA episode (DGA2) within two years of the first DGA, equivalent to 0.63% of overall DGAs. In summary, Repeat DGA episodes generally occurred around 2 years after the first DGA.

1.11 Dental Treatment and Dental General Anaesthesia

1.11.1 Treatment Planning

Prior to early 1990, it was common for DGAs to take place within a general dental practice (GDP) setting. Following publication of the Poswillo report, DGAs were limited to a hospital setting. However, it was still commonplace for GDPs to supply the treatment plan. This treatment plan was then adhered to by the hospital dentist completing the treatment under DGA. Harrison and Nutting found 31% of GDP referral requests were honoured at the DGA appointment, with remaining disease left untreated (Harrison and Nutting, 2000). 75% of these cases then required a DGA2 for caries left untreated at DGA1.

Fortunately, the practice of leaving untreated caries in situ is now outdated. The Guidelines for the use of GA in Paediatric Dentistry state 'the practice of extracting the most grossly carious and/or symptomatic teeth and leaving restorable teeth for future visits as an outpatient using LA with or without sedation is to be deprecated' (RCS England, 2008).

These guidelines are reinforced by a 2019 evaluation produced by Brown at al (2018). They found a statistically significant difference between GDP treatment plans and the

treatment that was ultimately performed under DGA. In 85% of cases, the GDP suggested treatment plan was changed following an assessment with a specialist in paediatric dentistry. In 12% of cases, the need for DGA was avoided all together (Brown et al, 2018). Similarly, one community dental service found that within one month of referrals, almost 300 more teeth were required to be extracted than had been identified by the GDP (Landes and Bradnock, 1996).

Further development on this area has been published in the Commissioning Guidelines for Paediatric Dentistry (NHS England, 2018). These guidelines aim to implement changes in the way paediatric dental treatment is provided in the UK, suggesting that all children receiving DGA should receive a treatment plan and subsequent treatment by a specialist or consultant in paediatric dentistry.

1.11.2 Radiographic Assessment

When considering treatment under general anaesthesia, the dentist should aim to complete all necessary pre-operative assessments. This includes a radiographic assessment, which is invaluable in the diagnosis of interproximal caries (Coplans and Curson, 1982; Davies et al, 2008).

The importance of radiographs in the diagnosis of interproximal caries is well documented in the literature (Bradley, 2014). A mouth may look caries-free, but bitewing radiographs provide an important adjunct to caries diagnosis that should be utilised where possible. All UK dentists should be familiar with the FGDPs Selection Criteria for Dental Radiography guidelines, which emphasizes the relevance of radiographs in caries diagnosis (Bradley, 2014).

Some dentists are under the misguided belief that children can’t tolerate radiographs, and therefore don’t attempt to take them. However, this is not always the case. One

study of 82 children, with an average age of 6, found only 10% found it ‘hard or ‘very hard’ to tolerate intraoral radiographs. The remaining 90% found it ‘very easy’ or ‘easy’ or didn’t mind (Subka, 2015).

Some dentists may also believe that radiographs won’t influence their treatment plan in very young patients. However, the FDGPs Dental Radiography guidelines suggest bitewing radiographs should be taken at routine intervals, following contact closure of primary molars. This usually occurs around age 4 (Bradley, 2014).

If pre-operative radiographs are not possible, operative radiographs may be considered. However, operative radiographs under DGA are not routinely used or reported on. Albadri et al found that whilst radiographs were available for 34.3% of patients at DGA1, only 21.2% of the repeat DGA group had pre-operative radiographs available (Albadri et al, 2006). Many similar studies have also identified very low availability of pre-operative or operative radiographs in repeat DGA patients (Jogezai et al, 2014; Timms et al, 2023, Lawson et al, 2017).

A report published by Lawson et al (2017) highlights the importance of radiographs and appropriate treatment planning in the reduction of repeat DGAs. This report also demonstrates significant carious interproximal lesions that appeared ‘sound’ without radiographic assessment.

DGA guidelines highlight the importance of reducing the operative time as much as possible, to reduce the risk of complications (Pike, 2000). Some dentists may misinterpret this, and place importance on the reduction of operative time over additional clinically necessary procedures that may prolong the DGA, such as operative radiographs.

The most precarious stages of a DGA are at induction and recovery, and therefore utilisation of operative radiographs is unlikely to influence the risk (Siddiqui and Kim, 2023). As also stated in many DGA guidelines, importance is placed on adequate and thorough treatment planning, of which radiographs are often an essential part of this (Adewale et al, 2011).

1.11.3 Operative Treatment

Extraction is the most common treatment at DGA2. Kakaounaki et al (2006) found the ratio of extraction to restoration has been reported to be 1.3 at DGA1 and 2.8 at DGA2. In children who had a single DGA, one study reported they had on average 4.6 teeth extracted at DGA1 and those who went on to have a repeat DGA has less teeth extracted at DGA1, on average 3.2 teeth (Kakaounaki et al, 2010).

Understandably, significantly more primary teeth are extracted under DGA than permanent teeth. This is potentially due to the young age of the child, limited cooperation, and extent of treatment (Savanheimo and Vehkalahti, 2014).

1.11.4 Follow-up

One study found that children who undergo DGA are a high-risk group for future poor oral health and dental anxiety as they get older (Vermeulen et al, 1991). It also found that DGA prevalence can predict burden of caries ten or more years following the DGA procedure. The authors suggest DGA status could be used in clinical practice or risk assessment models as risk factor for further disease or anxiety.

Multiple studies have found patients who receive repeat DGAs are less likely to attend follow-up appointments, and more likely to attend only when in pain. Figures range from 97% to 40% of repeat DGA patients fail to attend follow-up appointments (Sheller et al, 2006; Leagault et al, 1972). Furthermore, Kakaounaki et al (2010) found half of their

repeat DGA group had a history of irregular attendance. Similarly, Landes and Bradnock (1996) found 25% of their repeat DGA group only attended the dentist when in pain.

1.11.5 Oral Hygiene

Studies have found that children who require repeat DGA are more likely to have a diet high in sugar, poor dietary habits and less likely to follow an oral hygiene regime. This includes unsupervised tooth brushing in young children and continued use of a bottle after the age of 12 months (Kakaounaki et al, 2006). In many repeat DGA, children have received follow-up appointments and/or prevention advice prior to subsequent DGAs, which suggests advice has not been adhered to (Savanheimo and Vehkalahti, 2014).

One study found, following DGA 1, that all children were provided with a post-operative prevention plan. Of these children, 26% did not comply with this advice and the highest rate of repeat DGA (10%) was found in in this group (Sheller et al, 2006).

1.12 Characteristics of Children Receiving Repeat DGA

1.12.1 Dental Caries

Measuring caries recurrence following DGA1 is difficult for several reasons. Patients do not always return for follow up or may seek treatment elsewhere. It may be difficult to assess new caries due to the way records have been stored, or the way caries has been recorded previously. Regardless of this, there is overwhelming evidence to demonstrate dental caries as the primary reason for DGA and repeat DGAs.

Almeida et al found 78.5% of children who returned for follow-up assessments following DGA1 had new carious lesions. Of these children, 16.7% (7 children) required DGA2 (Almeida et al, 2000). A similar study by Graves et al (2004) examined 57 children 6-months after DGA1. They found 36.8% had one or more new carious lesions. Recurrent

caries was not reported. However, the authors did find that the type of treatment provided at DGA1 did not affect the risk of future caries development.

Foster et al found that 103 (53.4%) of 191 children who received DGA1 under the age of 7 developed new carious lesions within 24 months of DGA1. The examiners did not include recurrent caries in their definition of ‘new carious lesions’. For this reason, the incidence of new carious lesions may be higher than reported (Foster et al, 2006).

Kakaounaki et al found dental caries was stated as the reason for DGA1 and DGA2 in at least 84% of cases. 71.9% of teeth subsequently extracted at DGA2 were recorded as caries-free or unerupted at DGA1 (Kakaounaki et al, 2006). 84% of the teeth extracted at DGA2 were erupted at DGA1, suggesting the caries had developed to an unrestorable level in less than 6 years. A similar study found caries had developed in a shorter timeframe with 40 out of 162 children who received DGA1 having new carious lesions within 12-months of DGA1 (Amin et al, 2010).

1.12.2 Medical History

1.12.2.1 Medical Co-morbidities

Despite a limited number of studies reporting on repeat DGA and medically compromised children, there is strong evidence to indicate children with medical comorbidities are more likely to receive repeat DGAs in childhood.

Guidry et al (2017) found that patients aged 1 to 12 with medical co-morbidities were 4 times more likely to require a DGA2 than fit and healthy subjects, across a 5-year period. Similarly, Bucher et al (2016) examined 464 medically compromised patients. All patients had at least one medical co-morbidity. 50 children (11%) received a DGA2, and 7 children (1%) received a DGA3. 40% of these children had a congenital or chromosomal anomaly.

One retrospective Australian study examined repeat DGA rates in medically compromised children. They found a repeat rate of 4.3% out of 304 children in their first group, and a subsequent repeat rate of 2.3% out of 687 children in their second groups. Global Development Delay was the most prevalent comorbidity in children in both groups (D'Mello and Hallet, 2013).

Kakaounaki et al (2010) reported that 71% of their repeat DGA group (24 out of 34 children) had a significant medical history. The most common medical conditions were respiratory disorders (40/129) followed by cardiac (19/129) and neurological disorders (18/129). They found no significant difference between the number of extractions in healthy children compared to those with a significant medical history.

1.12.2.2 Dental Anxiety and Behaviour

Multiple guidelines advise that severe dental anxiety or dental phobia is a justifiable use of DGA, whilst highlighting the importance of other methods or adjuncts, such as behaviour management and sedation if appropriate (Adewale et al, 2011; Davies et al, 2008). However, in patients who are extremely nervous, alternative methods such as inhalation sedation are less likely to be effective (Gordon et al, 1998).

Sheller et al (2006) reported that children who required DGA2 generally showed challenging and unpredictable behaviour during their initial dental examinations compared those who required a single DGA within two years. This study does not however state the specific behaviours that were challenging. Morgan et al (2016) found the majority of children who received a DGA reported high levels of fear and anxiety regarding dental treatment.

1.12.3 Social History

1.12.3.1 Socioeconomic Status

Landes and Bradnock (1996) found that 23% of their DGA patients had previously received a DGA, and this had a positive correlation with their Jarman Score (an index used to measure social deprivation). This indicates children living in lower socioeconomic areas are more likely to receive repeat DGAs.

A similar study in Wales found children with parents working in manual occupations, parents who had never worked and those who visited the dentist only when in pain had greater odds of receiving DGAs. These are all factors linked with families living in socially deprived areas (Goodwin et al, 2015).

1.12.3.2 Social History Risk Factors

Sheller et al (2006) found a positive correlation between the need for repeat DGAs and parental factors such as the parent/carer not brushing a child’s teeth and a dysfunctional social situation. They found common characteristics of children requiring repeat DGA included the child being responsible for brushing their own teeth, poor cooperation, difficult personality as described by parents and a dysfunctional social situation. All of these factors are found in children with challenging social histories and dysfunctional family environments.

Challenges reported by parents in supporting their child's oral health included parenting skills, child behaviour, peer pressure, insufficient time, the dental system, and no plans for continuing care for their child (Ollet et al, 2011). Similarly, it has been reported that less educated mothers and those with lower incomes had higher dental anxiety scores and were correlated with a higher number of carious teeth in their children (Khawja et al, 2015).

1.12.3.3 Parental Dental Anxiety

Parental dental fear is strongly correlated with the behaviour of their children and the dentist and their subsequent dental anxiety (Themessl-Huber et al, 2010). It is well established that parental anxiety influences child's dental anxiety (Bridgman et al, 1999, Porritt et al, 2012).

Olley et al (2011) found a significant proportion (47%) of parents and guardians of children undergoing DGA had also received previous dental treatment under GA. A more recent study reported that 48% of parents accompanying children at 150 consecutive exodontia DGAs had also received a DGA in the past for extraction of carious teeth (Worthington et al, 1998). This highlights a lack of caries prevention and/or increased dental anxiety within families.

A 2015 study found a positive correlation between a child's caries experience and mothers dental anxiety. Of children with dental caries, half of mothers reported being 'anxious' or 'very anxious' about dental treatment. They also found a statistically significant difference in anxiety level of mothers related to the age of the child, mothers level of education and family income (Khawja et al, 2015).

1.12.3.4 Siblings Dental General Anaesthetic Experience

Goodwin et al examined 456 patients across six hospitals in the Northwest of England. They examined families and previous DGAs of other children within the family. Their results were high, ranging from 33-59% (Goodwin et al, 2015). This suggests that oral hygiene advice was not implemented across other family members.

1.13 Access to Care

1.13.1 Accessing Treatment

Ramdaw et al (2017) found the lifetime prevalence of DGA use was 9.1%, with children who only visited the dentist only when in pain having greater odds of needing a DGA. Three out of four parents (74%) reported that they would like support for their child's oral health. These findings suggest that the oral health support received by high caries risk children is low.

1.13.2 Attendance

It is understandable that children who fail to attend the dentist regularly, or those who are not brought follow-up appointments are more likely to have untreated dental caries. The longer the child goes without a dental appointment, the more likely problems will develop unnoticed, inevitably leading to a more extensive treatment plan (AAPD, 2015). One study found children who were irregular attenders were four times more likely to require a repeat DGA (Clewett and Treasure, 2004). Furthermore, children with at least one episode of pain and infection prior to DGA1 were also more likely to require a DGA2.

Sheller et al (2006) reported that only 7% of their DGA2 group attended their postoperative review appointment following DGA1, compared to 43% of DGA patients who only required one DGA within 2 years.

1.16 Conclusions of the Literature Review

Dental General Anaesthesia (DGA) is a costly and overused resource on the National Health Service (NHS). The provision of DGAs for extraction of decayed teeth, in children under the age of 18, costs the NHS roughly £30million a year. The majority of these DGAs are to remove decayed teeth, and DGA is the primary reason children in the UK are admitted to hospital (GOV.UK, 2022).

DGA is generally considered a safe procedure. Very serious risks such as death are rare, estimated at 1 in 3.5 million GAs (Roberts et al, 2020). Post-operative complications are common, such as nausea, vomiting, dizziness, a sore throat, and bleeding (Knapp et al, 2017). Pain and difficulty eating prior to the DGA are common, as is time off school (Rodd et al 2014).

Children from low socioeconomic backgrounds, other ethnicities and those with medical co-morbidities are more likely to require DGA. Parental dental anxiety, failure to bring children to necessary dental appointments and parental history of DGA are all associated with an increased likelihood of repeat DGA. Repeat DGA rates were higher in children who failed to attend for follow-up appointments, only attended the dentist when in pain, and those that had poor oral hygiene.

The overall prevalence of repeat DGA worldwide is reported between 2% and 24%, which is similar to the UK at 1.3% to 25%. The time interval between DGA1 and DGA2 was approximately 2-years.

In summary, DGA is generally considered a safe procedure, and rates of repeat DGA are low. Some children have characteristics that increase the likelihood of repeat DGA. The majority of repeat DGAs are to treat new carious lesions that have developed within

two years of the first DGA. As caries is a preventable disease, and some of these risk factors are modifiable, we may be able to reduce a patients repeat DGA risk.

1.17 Aims

The aims of this study were:

Part 1: Epidemiology Study

- Identify the prevalence of DGA in North Yorkshire Salaried Dental Services between January 2002 and May 2018.
- Identify the prevalence of repeat DGA in North Yorkshire Salaried Dental Services between January 2002 and May 2018.
- Identify the number of DGAs each DGA patient received.
- Identify characteristics of children more likely to receive repeat DGA.

Part 2: Case Control Study

- Identify potential risk factors for repeat DGA by comparing characteristics of children who received a single DGA to those who received repeat DGAs (DGA1 and DGA2).
- Determine significance of these risk factors using statistical methods.

2 Epidemiology Study

2.1 Introduction

The Hospital Episode Statistics (HES) database contains administrative data from English hospitals in the National Health Service (NHS). This database records inpatient episodes, outpatient episodes, accident and emergency attendance and critical care (Boyd et al, 2018).

This database has been used to identify national patterns in disease, attendance, and service differences across England. As the data are collected from hospital-based admissions, data on Dental General Anaesthetics (DGA) are not always included as they are often provided by external organizations, such as Salaried Dental Services (SDS) (Boyd et al, 2018). Furthermore, HES data does not isolate individual patients and therefore episodes of repeat DGA are not identifiable.

For this reason, collection and analysis of local data is required to develop greater understanding of current provision and demand of repeat DGA services. Since 2002, the North Yorkshire SDS have entered dental records into an electronic database. The electronic database, SOEL Health©, is utilised by all 11 dental clinics within the North Yorkshire SDS.

For this epidemiological study, key electronic data pertaining to children receiving more than one DGA episode was collected. This chapter first describes the methodology for the epidemiology study. This includes sample selection and data collection. The second part of the chapter presents the results both in terms of distribution of individual patient characteristics and repeat DGA prevalence. Finally, results and analysis are discussed.

2.2 Materials and Methods for the Epidemiology Study

2.2.1 Permission

Ethical approval for the study was granted by the Health Research Authority (19/LO/0115) (Appendix 1). Research and Development approval was granted for the 11 sites where individual DGA assessments were performed, by Harrogate and District Foundation Trust Ethics Committee (Appendix 2). Data was accessed and collected from the electronic database within the Harrogate Community Dental Services clinic.

2.2.2 Sample Selection

The study sample was acquired through a search of the SOEL Health© database. All records were searched, from the time SOEL Health© was introduced into the service in January 2002. All patients within the search criteria were included in the study.

Search parameters: All children (under the age of 18) attending the North Yorkshire SDS who received one or more DGA between January 2002 and May 2018.

2.2.3 Consent and Recruitment

Due to the retrospective nature of this study, it was not necessary to obtain consent from participants, or actively recruit patients.

2.2.4 Data Collection

A DGA episode within North Yorkshire SDS is added to the patients electronic record in the form of a specific code. This code can be searched for within the electronic database, and more than one use of the code can also be identified. The electronic database was searched for all patients receiving more than one DGA between January 2002 and May 2018.

Patient ID numbers were then entered into a Microsoft Office Excel 2010 spread sheet. Patient records were then searched using their ID number and data was collected from three broad categories.

The data collection sheet can be found in Appendix 3. The first category included patient demographics such as age, gender, region, and socioeconomic status. The second category included information pertaining to the patients history including medical history, social history, acute symptoms, and attendance. The third category contained information relating to the patients treatment, including radiographic assessment, number of extractions and restorations, prevention advice and follow-up plan. This was completed for each DGA episode the patient received.

All findings are reported according to the maximum number of DGAs the patient received. Essentially, there are five groups (2GA, 3DGA, 4DGA and 5DGA) of repeat DGA patients. Characteristics are then reported depending on the total number of DGAs, in order to determine distribution of characteristics depending on total DGA number.

A single investigator completed all data collection and subsequent analysis. The investigator worked within the North Yorkshire SDS and was familiar with the electronic database and its functions.

2.3 Interpretation of the Data

2.3.1 Descriptive Statistics

Data was transferred from the spread sheet to IBM SPSS Statistics version 29. Prevalence of repeat DGA was expressed as a percentage with 95% confidence interval. Shapiro-Wilk test of normality was carried out on all continuous data. Quantitative data was summarised using means and standard deviations.

Median values were given together with maximum and minimum values for comparison to other studies. Qualitative or categorical data was summarised using frequencies, proportions, or percentages.

2.3.2 Analysis

Pearson Chi square test was used to examine relationships between categorical variables. Mann-Whitney U test was used to compare quantitative data of two groups that was not normally distributed. Krushkal-Wallis test was used to compare quantitative data that was not normally distributed with more than two groups.

2.4 Results of the Epidemiological Study

2.4.1 Presentation of Results

The results presented are the findings from patients receiving more than one DGA within the North Yorkshire SDS between January 2002 and May 2018. The term DGA followed by a number represents the DGA number in the sequence of total number of DGAs received. DGA1 is considered the first DGA, DGA2 is the second DGA episode and DGA3 the third episode. The fourth DGA episode is DGA4 and the fifth DGA episode is DGA5.

2.4.2 Prevalence of Repeat Dental General Anaesthesia

2.4.2.1 Total Number of Dental General Anaesthetic Episodes

The total number of DGA episodes performed in North Yorkshire SDS between January 2002 to May 2018 was 6012. 5427 (95%) patients received a single DGA. 248 (4.3%) patients received 2 DGAs, 20 (0.4%) patients received 3 DGAs, 6 (1%) received 4 DGAs and 1 (0.01%) received 5 DGAs. Therefore, 275 patients received at least two DGAs. The number of DGAs per patient is summarised in Table 2.1. Overall, the rate of repeat DGA (two or more DGAs) was 4.8%. All DGA episodes occurred within a 16-year period.

Table 2.1 Number of Dental General Anaesthetic Per Patient from January 2002 to May 2018

Total number of DGAs	Number of patients	Number of DGA episodes per group	Percentage of overall number of DGAs
1	5427	5427	90%
2	248	496	8%
3	20	60	1%
4	6	24	0.4%
5	1	5	0.08%
Total	5702	6012	100%

2.4.2.2 Repeat Interval Between Dental General Anaesthetic Episodes

Table 2.2 details the average time between subsequent DGA procedures, in years and months. The mean length of time between DGA decreased with subsequent DGAs. The shortest length of time between 2 DGAs was 5 months, and the longest length of time was 7 years 6 months. There was an average of 3 years 5 months between DGA1 and DGA2, and a similar interval of 3 years 4 months between DGA2 and DGA3. The mean interval was slightly shorter between DGA3 and DGA4 at 3 years, with the DGA5 being required 18 months later.

Table 2.2 Mean Length of Time Between Successive Dental General Anaesthetic Episodes

DGA episode	Mean time interval	SD	Med	Min	Max
DGA1 – DGA2	3y 5m	21m	39m	5m	90m
DGA2 – DGA3	3y 4m	19m	39m	13m	57m
DGA3 – DGA4	3y	22m	33m	5m	70m
DGA4 – DGA5	1y 6m	-	-	-	-

SD = Standard deviation

Med = Median

Min = Minimum

Max = Maximum

2.4.3 Results by Patient Demographics

2.4.3.1 Geographical Location

York District Hospital provided DGA services to the majority of the region (64%), followed by Harrogate (18%) and Northallerton (18%) District Hospitals. Repeat DGA provision by hospital can be found in Table 2.3. The majority of DGA2 procedures were performed at York (56%), followed by Harrogate (23%) and Northallerton (21%). These findings compare with the geographical area supplied by each hospital.

For DGA episodes following DGA2, York again provided the majority (13) of DGA3 and DGA4 episodes. Harrogate delivered 9 DGA3, DGA4 and DGA5 episodes. Northallerton provided the fewest repeat DGA episodes with 4 DGA3 episodes and 1 DGA4 episode.

Table 2.3 Sequential DGA Episodes Provided by Hospitals Within North Yorkshire Salaried Dental Services from January 2002 to May 2018

Repeat DGA episode	Harrogate	York	Northallerton	N of repeat DGA episodes
	N (%)	N (%)	N (%)	
DGA2	57 (23%)	139 (56%)	52 (21%)	248
DGA3	6 (30%)	10 (50%)	4 (20%)	20
DGA4	2 (33%)	3 (50%)	1 (17%)	6
DGA5	1 (100%)	0 (0%)	0 (0%)	1
Total	66 (24%)	152 (55%)	57(21%)	275

N = Number of patients

2.4.3.2 Patient Age

Mean age at DGA episode was calculated for repeat DGA patients at each successive DGA. This is shown in Table 2.4. The number of patients displayed per DGA episode is presented as the number of patients who received ‘at least’ that number of DGAs.

Mean age at DGA1, was 5.4 years old. Ages at DGA1 ranged from 1 to 14 years old. The mean age at DGA2 was 9.1 years old. The mean age at subsequent DGAs was 12.7, 14.5 and 15 years old at DGA3, DGA4 and DGA5. This is shown in Table 2.3, according to maximum number of DGAs received.

The mean age at DGA1 decreases as the total number of DGAs received by each patient increases. Patients who received a total of 2 DGAs were 6y 5m on average at DGA1, compared to 5y 4m for those who received 3 DGAs. Patients who received a total of 4 DGAs were approximately 4y 5m at DGA1. The patient who received 5 DGAs across the 16-year time span was just 1y 10m at DGA 1. Chi squared test indicated that the difference in age across the groups was significant (chi square = 192.4, $p = <0.001$), and the younger the patient at DGA1, the more likely they are to receive increasing number of DGAs.

Table 2.4 Mean and Median Patient Age at Successive DGA Episode for Patients who Received Repeat Dental General Anaesthesia

DGA episode	Patients (N)	Mean age (years)	SD	Median	Min	Max
DGA1	275	5.4	2.51	5	1	14
DGA2	275	9.1	3.26	9	3	16
DGA3	28	12.7	3.01	12	7	16
DGA4	7	14.5	1.9	15	11	16
DGA5	1	15	*	15	15	16

N = Number

SD = Standard Deviation

*No data as a single value

2.4.3.3 Patient Gender

51.3% of patient receiving more than one DGA were male, and 48.7% were female. Gender was very similar for patients receiving 2 and 3 DGAs. More females received 4 DGAs, and the patient who received 5 DGAs was male. This is shown in Table 2.5.

For patients who received 2 DGAs and 3 DGAs, gender was equally split between males and females. The sample size for patients receiving 4 DGAs and 5 DGAs was very small, and therefore showed an increased percentage of females (66%) receiving 4 DGAs. The patient who received 5 DGAs was male. There was no significant difference according to chi squared test (chi square = 4.23, p = .376).

Table 2.5 Patient Gender and Number of Repeat DGA Episodes Received

Number of repeat DGAs (N of patients)	Male	Female
	Number (%)	Number (%)
2 DGA (248)	128 (51.8%)	120 (48.2%)
3 DGA (20)	10 (50%)	10 (50%)
4 DGAs (6)	2 (33.3%)	4 (66.6%)
5 DGAs (1)	1 (100%)	0 (0%)
Total (%)	141 (51.2%)	134 (48.8%)

N = Number

2.4.4 Results by Patient history

2.4.4.1 Acute Symptoms

Presence of acute symptoms are summarised in Table 2.6 according to the maximum number of DGAs received, based on findings at DGA1. The presence of acute symptoms at DGA1 was high. 60% of patients receiving 2 DGAs had complained of pain, swelling or antibiotic use at DGA1, compared to 90% of patients receiving 3 DGAs. 50% of those receiving 4 DGAs also reported acute problems at the time of DGA1. A summary of acute symptoms and frequencies reported can be found in Appendix 4.

There was no significant difference according to chi squared test (chi square = 3.15, p = .475). This indicates that reports of acute symptoms do not make it less likely a patient will require repeat DGAs.

2.4.4.2 Medical History

Medical history was reported according to the presence of neurological deficits. A summary of those reported can be found in Appendix 5. The majority of conditions were autism, learning difficulties, chromosomal abnormalities, genetic syndromes, and global development delay.

Findings show patients with neurological comorbidities were more likely to receive more DGAs. A third of patients receiving 2 DGAs reported a neurological disability, followed by 70% of those receiving 3 DGAs. All patients receiving 4 DGAs and 5 DGAs reported a neurological disability. This is summarised in Table 2.6. Chi squared test indicated this finding was significant (chi square = 65.595, p = <0.001).

2.4.4.3 Social History

Social History was reported according to the presence of a complicating social factor. A summary of these can be found in Appendix 6. The majority of complicating factors were looked after children, those under a child protection plan, those in foster care or living with someone other than a parent.

Social history risk factors reported were generally low (Table 2.6), with an incidence of 19% in patients receiving 2 DGAs and 10% of patients receiving 3 DGAs. There was no significance according to chi squared test (chi square = 7.937, p = .094).

2.4.4.4 Index of Multiple Deprivation

Index of Multiple Deprivation (IMD) rank is a measure of social deprivation. The lower the rank, the more deprived the area. IMD deciles were simplified into three groups, to aid with data representation and analysis. Low (1-4), medium (5-7) and high values (8-10). The mean IMD rank and subsequent group for patients receiving multiple DGA episodes is shown in Table 2.7. Interestingly, patients receiving more repeat DGAs were more likely live in a less deprived area than those receiving fewer repeat DGAs.

The IMD rank was looked at further within the context of maximum number of DGAs received. Overall, the mean IMD decile for each DGA group is over 50% as shown in Table 2.7. This means that the majority of patients live in areas in the least deprived half of country.

Patients receiving 2 DGAs and 3 DGAs on average lived in the 60th least deprived decile, followed by the 50th decile for patients receiving 4 DGAs. The patient who received 5 DGAs lived in an area in the top 20% of least deprived postcodes. Chi squared test indicated no significant difference between the IMD and maximum number of DGAs (chi square = 38.306, p = .365).

2.4.4.5 Attendance

Attendance was calculated as a percentage, based on the total number of appointments offered minus the number they attended. This produced the number of appointments the patient was not brought (WNB) to. The majority of patients who received a repeat DGA were not brought to at least one appointment, with rates of 11% - 16% across the groups, as shown in Table 2.6. Chi squared test indicated this finding was significant (chi square = 501.857, p = <0.001).

Table 2.6 Summary of Patient History Findings per Maximum Number of DGAs Received

Mean N or % at DGA1	Maximum DGAs Received By Patient				p
	2 DGAs (248 patients)	3 DGAs (20 patients)	4 DGAs (6 patients)	5 DGAs (1 patient)	
Age (y,m)	6y 5m	5y4m	4y 5m	1y 10m	<0.001
Gender (f)	48.2%	50%	66%	0%	.376
Acute Symptoms Present	60% (148)	90% (18)	50% (3)	0% (0)	.475
Neurological Factor Present	33% (83)	70% (14)	100% (6)	100% (1)	<0.001
Social Factor Present	19% (46)	10% (2)	14% (1)	100% (1)	.094
IMD decile	60th	60th	50th	80th	.365
% WNB	11%	13%	11%	16%	<0.001

y,m = Years, Months

(f) = female

IMD = Index of Multiple Deprivation

WNB = Was Not Brought

p = p value according to chi squared test

Table 2.7 Total Number of DGAs and Patient IMD Rank

Maximum Number (N) of DGAs		IMD Score		
		Low (N)	Moderate (%)	High (%)
2 DGAs	248	32% (79)	35% (86)	33% (83)
3 DGAs	20	10% (2)	35% (7)	55% (11)
4 DGAs	6	33% (2)	0% (0)	66% (4)
5 DGAs	1	0%	0%	1 (100%)
	Total	30% (83)	34% (93)	36% (99)

N = number

IMD score = index of Multiple Deprivation

2.4.5 Results by Treatment Provided

2.4.5.1 Radiographs

The incidence of radiographs either pre-operatively or taken during DGA1 was recorded, as shown in Table 2.8. With regards to pre-operative and operative radiographs pertaining to diagnosis and/or treatment planning for DGA1, some patients had pre-operative or operative radiographs, some had neither and some had both. Both forms of radiographic assessment were used to represent radiographic data in table 2.8.

Overall, very few patients had radiographs available at DGA1. For those who received 2 DGAs, 53 patients received pre-operative radiographs and 26 patients received operative radiographs during DGA1. One of these patients had both pre-operative and operative radiographs. Those receiving 3 DGAs were unlikely to have radiographs. Only 2 patients had pre-operative radiographs available, and only 2 had radiographs taken during DGA1. Out of the patients who received 4 or 5 DGAs, none of them had radiographs available at the pre-operatively or operative stage at DGA1.

Chi squared test found a significant association between the lack of pre-operative radiographs and an increased likelihood of repeat DGA (chi square = 59.564, p = <0.001). Operative radiographs were not found to be significant (chi square = 5.446, p = .245).

2.4.5.2 Number of Restorations

The number of restorations carried out at DGA1 was generally low. This increased slightly in patients who received a higher number of DGAs. Table 2.8 demonstrates the mean number of restorations. For patients who received 2 DGAs, the mean number was 0.8 followed by 2.2 for those receiving 3 DGAs. Those who received 4 DGAs were most likely to have restorations placed at DGA1, with an average of 2.8.

Chi squared test indicated this was significant (chi square = 90.459, p = <.001), suggesting patients who receive a higher number of restorations at DGA1 are more likely to receive a higher number of DGA procedures.

2.4.5.3 Number of Extractions

As shown in Table 2.8, patients who received 2 DGAs had an average of 5.3 teeth extracted at DGA1. Those who received 3 DGAs had an average of 7 teeth extracted, followed by 4.8 teeth for those receiving 4 DGAs. The patient who received 5 DGAs only

had two teeth extracted at DGA1. Chi squared test did not find this significant (chi square = 94.458, p = .019).

2.4.5.4 Prevention Advice

10% of patients who received 2 DGAs had no record of preventative advice documented in their electronic notes. The remainder of patients (90%) did receive oral hygiene instruction (OHI) at some point prior to their DGA1 procedure (Table 2.8). The majority of patients had OHI provided on multiple occasions. This was generally provided by the dentist, and not at a separate Oral Health appointment. Interestingly, chi squared test indicated patients who did not receive preventative advice were less likely to receive more than 2 DGAs (chi square = 18.749, p = <.001).

2.4.5.5 Follow-up

Most patients who received more than one DGA were offered a follow-up appointment within the SDS, with only 10% of patients in DGA2 not being offered one. This is shown in Table 2.8. This correlates with provision of oral hygiene instruction, as OHI instruction had to be given prior to the offer of a follow-up appointment. However, attendance at the follow-up appointment was not recorded.

Chi squared test indicated that follow-up within the SDS was significant (chi square = 32.532, p = <.001), with those who received more DGAs more likely to receive SDS follow-up.

Table 2.8 Summary of Treatment Provided at DGA1 According to Total Number of DGAs Received

N = Number

p = p-value according to chi-squared test

Mean (N or %) at DGA1	N of Total DGAs Received By Patient				p
	2 DGAs (248 patients)	3 DGAs (20 patients)	4 DGAs (6 patients)	5 DGAs (1 patient)	
Pre-operative radiographs % (no. of patients)	21% (53)	10% (2)	0% (0)	0% (0)	<0.001
Operative radiographs % (no. of patients)	10% (26)	10% (2)	0% (0)	0% (0)	.245
Number of Teeth Restored	0.8	2.2	2.8	0	<0.001
Number of Teeth Extracted	5.3	7	4.8	2	.019
Prevention advice % (no. of patients)	90% (224)	100% (20)	100% (6)	100% (1)	<0.001
Follow-up % (no. of patients)	90% (224)	100% (20)	100% (6)	100% (1)	<0.001

2.4.6 Summary of the Epidemiology Study Results

- A total of 6012 DGA episodes were performed.
- 275 patients received repeat DGAs. 248 patients received 2 DGAs, 20 patients received 3 DGAs, 6 patients received 4 DGAs and 1 patient received 5 DGAs.
- The overall prevalence of repeat DGA was 4.8%.
- The average time between DGA1 and DGA2 was 3 years and 5 months.
- The younger the patient at DGA1, the more likely they were to receive more than one repeat DGA.
- Males and females had equal chance of repeat DGA.
- Reports of acute symptoms such as pain did not make it less likely a patient would require repeat DGA.
- Patients with a neurological comorbidity were significantly more likely to require repeat DGA.
- Complex social histories did not change the likelihood of repeat DGA.
- There was no association between IMD and number of repeat DGAs.
- Patients who were not brought to appointments were more likely to receive repeat DGAs.
- Presence of radiographs was limited in all patients.
- Lack of pre-operative radiographs increased the likelihood patients would receive multiple repeat DGAs.

- Patients who received a higher number of restorations at DGA1 were more likely to receive multiple repeat DGAs.
- Patients who received a higher number of extractions at DGA1 were less likely to receive multiple repeat DGAs.
- Preventative advice was provided to the majority of patients (90%).
- Provision of preventative advice was correlated with an increased number of repeat DGAs.
- Patients with more DGA procedures were more likely to receive follow-up within the SDS.

2.5 Discussion of the Epidemiology Study Results

This section discusses the epidemiological research. This epidemiology study forms the foundation of the Case Control study presented in part 3 of this thesis. This discussion will focus on distribution of characteristics in patients receiving more than one DGA. The remaining discussion can be found in part 3.

2.5.1 Discussion of Epidemiology Methodology

2.5.1.1 Location

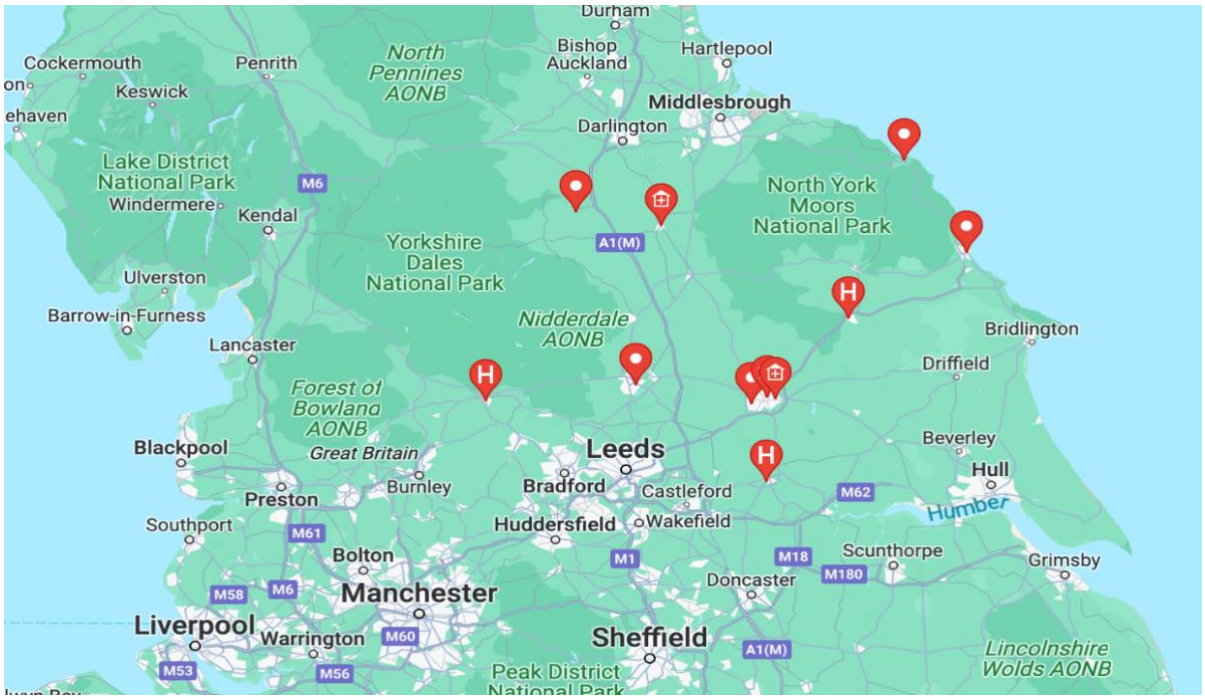
North Yorkshire SDS covers the county of North Yorkshire. North Yorkshire is the largest country in England, with a population of roughly 1.2 million people. The SDS includes 11 dental clinics, covering the following regions: Hambleton & Richmondshire, Scarborough, Whitby & Ryedale, Selby & York, and Harrogate (Figure 2.1). Each DGA procedure is performed at one of three main hospitals (Table 2.1).

The region was selected for a number of reasons. Firstly, the chief investigator worked in multiple clinics within the North Yorkshire SDS, and frequently used the electronic database. Secondly, it was anticipated valuable results could be obtained from a large and varied sample. Finally, the widespread use of the electronic database allowed the investigator to access extensive patient information securely without the need for paper notes.

2.5.1.2 Sample Selection

Following a search of the electronic database, all patients identified as having received more than one DGA were used in the study. Due to availability of data and the length of time it was available, the investigator decided to collect relevant information from each DGA episode. Those with incorrect codes were not included, and this therefore left 275 suitable patients with all relevant data.

Figure 2.1 Location of 11 Dental Clinics Within North Yorkshire Salaried Dental Services (HDFT, 2024).



In similar studies comparing patients with a single DGA to repeat DGA, patients have been matched. However, it was felt matching patients would negatively affect the availability of data, and the distribution of characteristics within the population of North Yorkshire (Sheller et al, 2006).

There are no studies demonstrating data collection over a 16-year period or longer. A similar study described by Vertullo et al (2021) analysed retrospective data collected over a 10-year period. Although the data period was shorter, there were significantly more patients involved in the study spanning a larger geographical area.

2.5.1.3 Data Collection

Data collection was completed by the chief investigator (CI). The CI was familiar with the SOEL Health electronic database and used it frequently to record clinical notes. The CI used Harrogate Community Dental Clinic as this is one of the larger clinics, and where the CI worked most of the time.

2.5.2 Discussion of Epidemiology Results

2.5.2.1 Patient Demographics

2.5.2.1.1 Age

Mean age at DGA2 is generally reported between age 6 and 9 (Kakaounaki et al, 2010; Leagault, 1972, Almeida et al 2000) although some studies have reported considerably lower ages. Sheller et al (2003) reported a mean age of just 4.7 years at DGA2. However, this study was completed prior to the implementation of many guidelines we use in paediatric dentistry today (RCAO, 2022).

Mean ages at subsequent DGAs were found to be higher than those described by studies presented in Table 2.9. The time span of the study may explain these differences. These studies ranged from 9 to 10-years, compared to 16-years in our study. The larger timeframe allows more time for repeat DGAs to be identified but will also identify older patients with a longer interval between DGAs and therefore increase the mean age at subsequent DGAs.

As expected, mean age increased at each successive DGA episode. The increases in age became progressively smaller as the number of DGAs increased. This finding was noted in all studies.

2.5.2.1.2 Gender

Many studies support the conclusion that gender does not appear to have an effect on the likelihood of repeat DGA. Most have found comparable results in terms of gender differences, with an equal, or almost equal split between males and females. Schroth and Smith (2008) reported an equal number of males and females at each DGA. Kakaounaki et al (2010) reported similar findings, of 239 males and 245 females.

Interestingly, Vertullo et al (2021) reported 63.8% of patients were male in their study of repeat DGA episodes. However, this was not found to be significant.

Table 2.9 Studies Reporting Mean Patient Age at Successive DGAs

Study Author	Length of study	DGA2	DGA3	DGA4
Vertullo et al (2021)	10 years	7.6 years	9.6 years	11.2 years
Bucher et al (2016)	9 years	5.5 years	8 years	8 years
Schroth and Smith (2008)	9 years	5.5 years	6.2 years	7.2 years

2.5.2.1.3 Index of Multiple Deprivation

It is widely accepted that children living in deprived areas are more likely to suffer from decay (NDEP, 2023). In England, the Index of Multiple Deprivation (IMD) is used to determine the level of deprivation associated with an area (90). Social deprivation is reported in different ways in the literature, with some studies using recognised scales such as IMD. Other studies reported descriptive characteristics, whilst most did not collect socioeconomic data (Landes, 2002).

This study found the number of DGAs provided by each hospital was comparable to the size of the geographical area supplied by the hospital. The mean IMD scores for each DGA group were all within the 50th to 80th centiles, towards the least deprived areas in England. The IMD score and number of DGAs was not significant.

This finding was similar to that reported by Goodwin et al (2015). Their study analysed repeat DGA data in six different hospitals in the Northwest of England. The average IMD scores of those attending for DGA were significantly different to the overall population of

each hospital region, highlighting the importance of analysing the socioeconomic status of the individual patient. Interestingly, they found patients with higher IMD scores were more likely to attend appointments, which may have been a confounding factor.

2.5.2.2 Patient History

2.5.2.2.1 Medical History

The presence of a neurological condition was highly correlated with the number of repeat DGAs. 30% of patients receiving 2 DGAs had a neurological disability, followed by 70% of those receiving 3 DGAs. All patients receiving 4 DGAs and 5 DGAs had a neurological disability.

These findings are comparable with other studies. D'Mello & Hallet (2015) reported a repeat DGA rate of 2.3% in medically compromised patients. Global developmental delay was the most common comorbidity in their repeat DGA group. Bucher et al (2016) reported a repeat DGA rate of 10.8% over a 9-year period. All patients in this study had one or more medical comorbidity. Congenital and chromosomal abnormalities were the most common diagnosis. Jogezai et al (2014) reported 30% of patients at DGA2 had learning disability.

Overall, the literature clearly suggests medically compromised patients and more specifically those with neurological disabilities are more likely to receive multiple DGA episodes. Notably, Guidry et al (2017). reported medically compromised children were more four times more likely to receive repeat DGA compared to healthy children.

There were no studies that reported on DGAs that were coordinated with other medical specialties (AAPD, 2016). These are sometimes performed on children with complex medical issues that require an additional general anaesthetic, such as a surgical procedure. Where possible, the dental treatment is completed at the same time, to

minimise the number of DGAs required. These are more likely to be performed in general hospitals rather than smaller district hospitals.

Interestingly, Vertullo et al (2021) found 50% of their repeat DGA had a neurological comorbidity, with autism, global development delay and genetic syndrome being the primary diagnoses. As the number of medically compromised patients was equal to fit and healthy patients, the association of medical history and repeat DGA could not be determined.

2.5.2.2.2 Social History

It is widely accepted that children with more complex social histories are more likely to have dental caries (NDEP, 2023). Complexities may include the involvement of a social worker, foster care, child protection plans and children living with someone other than a parent.

Few studies have reported on social factors and incidence of repeat DGA. In this study, almost 20% of patients who received 2 DGAs had a complex social history. However, this was not found to be significant, and the effect decreased as the number of repeat DGAs increased.

Sheller et al reported a dysfunctional social situation increased the likelihood of repeat DGA procedures amongst their study group (38), although the significance of this was not clear.

2.5.2.2.3 Acute Symptoms

In this study, the presence of acute symptoms at DGA1 was high, ranging from 50% - 90% depending on the total number of DGAs received. There was no significant difference between groups. This suggests that a child who has previously reported

symptoms such as dental pain has no less risk of future DGAs than a child who has not reported previous symptoms.

It is reasonable to assume that parents who have experienced a child suffering with dental pain, along with sleepless nights, swelling, time off school and resultant DGA, would be more vigilant with oral hygiene and caries prevention. However, these findings combined with the fact that repeat DGAs are happening, do not support this assumption.

Kay (1989) found 35% of parents in socially deprived areas of Scotland felt dental disease would be most satisfactorily managed by the dentist, and that their child was unlikely to suffer from disease, even without any preventative action. This suggests some parents are more likely to place responsibility with the dentist (Kay and Blinkhorn, 1989).

Parents report feelings of guilt following their child's DGA and the desire to improve preventative practices (Baghdadi et al, 2021). In one study, parental guilt, and desire to avoid DGAs was the driving factor in improved oral hygiene and changes in dietary habits. However, the effect was only short-term (93). A similar study by Amin and Harrison (2009) reported similar findings with caries prevention methods improving after a DGA, but with limited short-term effect. Parents reported challenges such as time, social media, and attitudes of the dentist.

It is clear one of the main challenges is parental behaviour change. Short-term behaviour change coupled with the finding that repeat DGAs occur approximately 25 months after the first is evidently not enough to change this risk.

2.5.2.2.4 Attendance

This study examined appointment attendance and provision of a follow-up appointment, although attendance at follow-up appointment was not recorded. Lack of attendance

was found to be significantly associated with repeat DGAs. The majority of patients receiving at least 2 DGAs were not brought to at least one appointment.

This finding is supported by a number of studies. Kakaounaki et al (2010) found half of their repeat DGA group had a history of irregular attendance. Similarly, Landes and Bradnock (1996) found 25% of their repeat DGA group only attended the dentist when in pain.

Many studies into repeat DGA episodes report a high number of patients fail to attend follow-up appointments. Legault et al (1972) reported 40% of their repeat DGA failed to attend follow-up appointments, and Sheller et al found only 7% of repeat DGA patients attended follow-up appointments. Therefore, the rate of repeat DGA may have in fact been higher.

2.5.2.3 Treatment Provided

2.5.2.3.1 Type of Dental Treatment

The type of dental care provided under general anaesthetic varies significantly. The type of dental treatment available is often split in ‘lists’. This is to ensure theatre time is maximised whilst minimising the time the patient is under anaesthetic.

Some providers have the means to provide ‘comprehensive care’. Comprehensive care often includes all treatment that is clinically necessary, such as radiographs, extractions, restorations, and stainless-steel crowns (Bucher et al, 2016). In some centres, comprehensive care is only available for select cases, such as those with medical comorbidities (Kakaounaki et al, 2006).

Other centres are only able to provide extractions under general anaesthetic. The potential to take radiographs on ‘extraction only’ lists may exist, but this is certainly not guaranteed. Lastly, some centres will provide a mixture of treatments on a ‘list’, such as

extraction only cases, and comprehensive care. Some providers will place ‘hall crowns’ but no other restorative treatment.

For this reason, data regarding treatment provided is often skewed or limited as there is no option to provide other treatments or investigations (such as radiographs) even if they were indicated.

2.5.2.3.2 Radiographic Assessment

Few studies reported the presence of radiographic records either pre-operatively or those taken during the procedure. This study found very few patients receiving repeat DGA had pre-operative or operative radiographs available, and most of the treatment was carried out without radiographs. Jogezai reported only 30% of repeat DGA patients had radiographs available (Jogezai et al, 2014), supported by Albadri et al who found only 20% of repeat DGA patients had a radiographic assessment (Albadri et al, 2006).

Presence of radiographs is very low in all repeat DGA studies, except for one by Bucher et al (2016). They reported the provision of comprehensive dental care for all 464 patients receiving a DGA. All patients were medically compromised. This included necessary radiographs. Interestingly, the rate of repeat DGAs was still 11% for 2 DGAs and 2% for 3 DGAs, similar to that of studies where radiographs were not available.

Interestingly however, the incidence of repeat DGA was still high (11% DGA2 and 7% DGA3). Initially, this may suggest that use of radiographs and comprehensive care did not affect the likelihood of further DGAs. However, it is important to note that all patients in this study were medically compromised, with chromosomal anomalies being most prevalent. Therefore, routine prevention and dental care is unlikely to prevent the need for future DGAs (Bucher et al, 2016).

A report by Deery et al (2015) suggests that radiographs may not be taken during the DGA procedure as clinicians are concerned about the length of time under anaesthetic. It goes on to explain this is misguided, as the greatest anaesthetic risks exist during induction and recovery. Furthermore, the risks associated with anaesthesia increase if another DGA is required, so dentists should try mitigating this risk by taking radiographs and all treatment necessary at this initial DGA.

2.5.2.3.3 Restorations

This study found few restorations were placed overall. The number of restorations placed at DGA1 increased as the total number of DGA procedures increased. This was found to be significant. DGA procedures in North Yorkshire SDS are primarily restricted to ‘extraction only’ cases. Some patients do receive comprehensive care, but these lists are limited, and the majority of patients are medically compromised.

Therefore, this finding may reflect the medically compromised nature of children receiving multiple repeat DGAs and their increased likelihood of receiving comprehensive dental care, and therefore more restorations at the DGA1 stage.

There were no comparable studies reporting the number of restorations at DGA1 depending on the maximum number of DGAs received. However, some studies did report the mean number of extractions and restorations at successive DGAs. Kakaounaki reported considerably less restorations overall, but the number of restorations did increase with successive DGAs (Table 2.10) (Kakaounaki et al, 2006).

Bucher et al (2016) and Smith and Schroth (2007) reported higher number of restorations (Table 2.10). Interestingly, the number decreased with successive DGAs for Bucher et al. This may be explained by the fact all patients received comprehensive care, so all available treatments will have been provided at each DGA.

Table 2.10 Studies Reporting Number of Restorations and Extractions at DGA2 and DGA3

Authors	DGA2		DGA3	
	Restorations	Extractions	Restorations	Extractions
Kakaounaki et al (36)	0.4	4.4	0.75	4
Bucher et al (78)	3.8	1.55	2.9	3.75
Smith and Schroth (48)	3.7	2.8	3.9	2.4

2.5.2.3.4 Extractions

Mean number of extractions at DGA1 ranged from 7 to 2, depending on the maximum number of DGAs the patient received. Those who received more DGAs were more likely to receive more restorations, and fewer extractions at DGA1. This finding correlates with that reported by Bucher et al as shown in Table 2.10. The majority of patients receiving more than 2 DGAs in our study were had a neurological comorbidity, similar to patients in Bucher et al. study (2016).

2.5.2.3.5 Prevention Advice and Follow-Up

This study reported the provision of oral hygiene instruction to all patient and parents, at least once, in their DGA journey. The majority of patients received this multiple times. However, it may have been more useful to record the implementation of this advice by parents, as it is not clear what was followed. One of the main challenges in improving oral hygiene in children is parental behaviour change (Kay and Blinkhorn, 1989).

Prevention and follow-up appointments are closely linked in this study. The electronic database includes a checkbox where prevention advice has been ticked prior to provision of a repeat DGA and allocation of a follow-up appointment.

The more DGAs a patient received, the more oral hygiene advice (OHI) they received. However, evidently parents found it difficult to implement oral hygiene improvements as the provision of OHI is inversely correlated with an increase in number of repeat DGAs. One factor to consider is that OHI was more likely to be reiterated to parents at multiple appointments because the patient possessed some form of risk factor that increased their risk, such as lack of motivation or neurological deficit.

Pine et al (2020) studied implementation of structured oral hygiene advice in a test group of 241 patients. The advice was delivered by dental nurses in motivational interview style, with a focus on specific goals such as caries prevention. They found a 51% reduction in likelihood of new caries developing, and 29% decrease in new caries experience compared to a group of children who had received generic non-specific advice regarding expected tooth eruption.

This interesting study highlights a new and novel way of delivering dental prevention advice, and the importance of personalised and unambiguous goals.

Furthermore, it would be more useful to assess parental motivation and uptake of advice in future, as it is clear parental motivation is lacking in patients who receive repeat DGAs, and the majority of repeat DGAs are to treat caries. Kakaounaki et al (2010) found half of their repeat DGA episodes were due to re-referrals from GDPs after the patient had been discharged due to lack of attendance, as a result of an emergency visit or had failed to attend multiple appointments.

2.5.3 Discussion of Repeat Dental General Anaesthetic Prevalence

2.5.3.1 Prevalence of Repeat Dental General Anaesthetic

Table 2.11 displays the prevalence and mean time interval between all repeat DGA episodes described in individual studies. The prevalence of repeat DGA ranges from 1.1% to 24%, with a mean prevalence of 10%. As shown in Table 2.11, studies vary significantly in the number of patients who received repeat DGA procedures, and the length of time investigated.

In our study, the overall prevalence of repeat DGA was 4.8%. This appears to be towards the lower end of rates found in similar studies. It is the lowest repeat rate found in studies that spanned more than 9-years. Promisingly, the 16-year time span of this study is likely to have improved the identification of patients who received repeat DGAs. If the time period was shortened, all repeat DGAs may not have been identified.

2.5.3.2 Interval Between Repeat Dental General Anaesthetic Episodes

The mean number of months between repeat DGA episodes is 24 months, although this varies from 14 months to 34 months. Our study found a mean time interval of 38 months between DGA1 and DGA2, with the interval decreasing as the number of DGAs increased. This figure is considerably higher than the average length of time reported by other studies. This is shown in Table 1.1 in the literature review.

One explanation for this could be the mean time interval is skewed as the study spanned 16-years. There are likely to be a number of outliers with significant lengths of time between DGAs. For example, one patient had more than 7 years between DGA3 and DGA4. This again would support the argument for a shorter timespan to eliminate outliers that may confound the data.

One limitation of this study is the definition of a repeat DGA, and what is considered unacceptable. Analysing the prevalence of repeat DGA over a shorter time period may have been beneficial. The majority of studies span less than five years, and this may be more appropriate in terms of unnecessary DGAs.

2.6 Summary of the Epidemiology Study Discussion

The purpose of this epidemiology study was to identify and compare patient characteristics of patients at DGA1, based on the total number of DGAs they received in childhood.

The number of repeat DGAs per area was found to consistent with the percentage of the region supplied by each of the three hospitals. Therefore, no areas performed significantly more or less DGAs than other areas, and they were evenly spread out.

Age at DGA1 was found to decrease as the total number of DGAs increased. This finding was significant. This therefore suggests that the younger the child at DGA1, the more likely they are to receive further DGAs, and this likelihood increases as age decreases.

There was no difference in gender and number of DGAs received. Acute symptoms were present in a high number of all patients, regardless of the number of DGAs they received. There was no significant difference between acute symptoms at DGA1 and the number of DGAs they went on to receive.

Presence of a neurological disability was significantly associated with the total number of DGAs received in childhood. Whilst 30% of patients receiving 2 DGAs had a neurological disability, this increased to 70% of all patients who received 3 DGAs, and 100% of all patients who received 4 and 5 DGAs. This strongly suggests patients with

neurological disabilities are significantly more likely to receive an increasing number of DGAs.

Index of Multiple Deprivation was measured based of postcode. There was no correlation between the maximum number of DGAs received and IMD rank. This does not support the common concept that children living in more socially deprived areas are more likely to require DGA. However, another factor association with social deprivation is attendance to appointments. The percentage of appointments the patient was not bought to was found to correlated with the total number of DGAs received.

The number of patients who received radiographs at DGA1 decreased as the number of DGAs increased, and this finding was significant. Radiographic assessment at DGA1 for patients receiving repeat DGAs was generally low, both pre-operatively and operatively. Only 25% of those receiving 2 DGAs had radiographs available. 30% of those DGA3 had a radiographic assessment completed and no radiographic assessments were performed for patients who had 4 and 5 DGAs. This finding is concerning and highlights the essential need for radiographic assessments in the diagnosis of caries and overall treatment planning.

In terms of treatment provided during DGA1, the number of restorations was significantly higher as the total number of DGAs increased. Overall, the number of restorations provided at DGA1 was generally low. The number of extractions was higher overall, and most patients received extractions. No significance was found with regards to the number of extractions and total number of DGAs.

Prevention advice was significantly more likely to have been provided at DGA1 as the number of total DGAs increased. Clearly, this effect is not due to improvements in oral health, or the opposite would have been true. It is more likely that prevention advise was

reinforced and documented for patients who were deemed higher risk, such as those with medical co-morbidities.

Prevention advice was linked to follow-up appointments, as the electronic database required an oral health advise box to have been selected in order to create a follow-up appointment within the system. Similarly, the total number of DGAs was associated with an increase in follow-up appointments offered. This is again likely due to patients deemed at higher risk such as those with complex medical histories.

The overall prevalence of repeat DGA was 4.8%. Most repeat patients received 2 DGAs. Fewer received 3 and 4 DGAs, and only 1 patient received 5 DGAs within the 16-year time. On average, the time between DGA1 and DGA2 was 3 years and 5 months. However, the time decreased as the number of total DGAs increased. This suggests patients requiring more DGAs were developing dental problems at a faster rate than those requiring fewer DGAs.

Overall, this study found that the presence of a neurological disability along with number of restorations at DGA1, age at DGA1 and number of missed appointments all increased significantly in patients as the total number of DGAs they received increased.

3 A Study of Risk Factors for Repeat Dental General Anaesthetic Results of the Case Control Study

3.1 Introduction

Since 2002, dental records have been entered into an electronic database within the North Yorkshire Salaried Dental Services (SDS). This multi-clinic database is unique as it shared by all 11 dental clinics that deliver the North Yorkshire SDS. This case control study used this database to relate patient characteristics and events to the incidence of multiple episodes of dental treatment under general anaesthetic. Key electronic data pertaining to the patients demographics and treatment history were obtained. A control group was made up of children who had received a single dental general anaesthetic.

The first part of this chapter describes the methodology for the study including patient selection and retrieval of data. The second part presents the results and analysis, initially by examining each factor individually (univariate analysis) and then by considering the most important factors as a group (multiple regression analysis). Finally, the results of the case control study are discussed.

3.2 Materials and Methods for the Case Control Study

3.2.1 Permission and Training

Ethical approval for the study was granted the Health Research Council (19/LO/0115) (Appendix 1). Research and Development. Research and Development approval was granted for retrieval of data by Harrogate and District Foundation Trust Ethics Committee (Appendix 2). Data was accessed and collected from the electronic database SOEL Health from within the Harrogate Community Dental clinic.

3.2.2 Study (Repeat Dental General Anaesthetic) Group

The study sample consisted of children attending specialist paediatric dental clinics within North Yorkshire SDS who received more than one Dental General Anaesthetic (DGA). The provision of a DGA is added to the electronic database in the form of a specific code. This code was then be searched for within the database.

3.2.2.1 Inclusion Criteria for the Study (Repeat DGA) Group

The inclusion criteria for the study group were as follows:

- Children who received more than one DGA between January 2002 and May 2018 within the North Yorkshire Salaried Dental Services
- Children under 18 years of age at the last DGA date

3.2.2.2 Exclusion Criteria for the Study (Repeat Dental General Anaesthetic) Group

The exclusion criteria for the study group were as follows:

- Children who did not receive more than one DGA between January 2002 and May 2018 within the North Yorkshire SDS
- Children aged over 18 years of age at the repeat DGA date.
- Children who are known to have received a DGA outside of North Yorkshire SDS

3.2.3 Control Group

The control sample consisted of children who received a single DGA within the North Yorkshire SDS.

3.2.3.1 Inclusion Criteria for the Control Group

The inclusion criteria for the control group were as follows:

- Children who received a single DGA between January 2008 and December 2012 within the North Yorkshire SDS
- Children under the 18 years of age at the date of the DGA

3.2.3.2 Exclusion Criteria for Control Group

- Children who received more than one DGA between January 2002 and May 2018 within the North Yorkshire SDS
- Children over the 18 years of age at the date of the DGA
- Children who are known to have received a DGA outside of the North Yorkshire SDS

3.2.4 Calculation of Sample Size

Sample size was determined by the number of patients who met the inclusion criteria in the study group. The size of the control group was then matched to this. The number of patients in each group was matched for a number of reasons. Firstly, to improve validity of the study, due to the difference in number of patients identified for the repeat DGA (275 patients) and single DGA (5427 patients) groups. Secondly, it would not have been possible to collect the desired data from all 5427 patients who received a single DGA.

3.2.5 Recruitment of Participants

This study involved retrospective assessment of an electronic database and therefore no active participants were recruited to this study.

3.2.6 Data Collection

Specific parameters were used to search the electronic database to identify patients for the study group and the control group.

The search parameters for the study group were:

1) Treatment Code: Including two or more of the following: -
    i. GA – Exodontia/Laryngeal Mask
    ii. GA – Intubation
    iii. Laryngeal Mask
2) Treatment Date:
    i. Between 01 January 2002 and 28 May 2018
3) Patient Age:
    i. Patients under the age of 18

The search parameters for the control group were:

1) Treatment Code: One of the following: -
    ii. GA – Exodontia/Laryngeal Mask
    iii. GA – Intubation
    iv. Laryngeal Mask
4) Treatment Date:
    i. Between 01 January 2002 and 28 May 2018
5) Patient Age:
    i. Patients under the age of 18

The initial database search was performed out by a Senior Dental Officer (SDO) known as the ‘Master User’. The ‘Master User’ is a senior clinician who is responsible for advanced functions on the electronic database, including complex searches. Patient ID numbers were identified and generated into an Excel spread sheet. This spread sheet was supplied to the chief investigator.

All suitable patients identified for the study group were used. The sample size for the control group was then matched to the number of patients in the study group. A random number generator was used to select these patients from the control group list.

3.2.7 Information Collected

The electronic database was searched using ID numbers and the patients date of birth and postcode. These were entered into the spread sheet, replacing the ID codes. Data collection was then completed by the chief investigator. The data collection form featured variables felt to influence DGA incidence. This was developed by the chief investigator, using information from existing literature and advice from knowledgeable consultants. Data was collected for the first episode of DGA, in both the control and study groups.

The data collected was split into two categories – information pertaining to the child’s demographics and history, and information pertaining to the treatment provided. In terms of patient demographics, information included the patients age, gender, medical and social history, appointment attendance and presence of acute symptoms. In terms of the treatment provided, information included the provision of preventative advice and preoperative radiographs, the operator grade, the number of restorations and extractions provided, and the type of follow-up. For both groups, data was collected from the first episode of DGA. Data from each form was entered into the spread sheet. Once data had been entered, the paper form was shredded and disposed of in confidential waste.

Figure 3.1 Summary of the Information Collected in the Case Control Study

Information Collected	Notes
Date of Birth	Age at DGA
Gender	Male or Female
Postcode	Index of Multiple Deprivation Decile
Medical History	Neurological Deficit – Yes/No
Social History	Relevant Social Factor – Yes/No
Acute Symptoms	Pain, Swelling or Antibiotics – Yes/No
Attendance	Total Number of Appointments Booked Number of WNB (Was not bought) Appointments
Pre-operative Radiographs	Yes/No
Caries Prevention Advice	Yes/No
Treatment	Radiographs – Yes/No, Restorations/ Extractions
Operator Grade	Dental Core Trainee / Dental Officer / Paediatric Dentistry Registrar / Specialist in Paediatric Dentistry / Consultant in Paediatric Dentistry
Follow-up In SDS	Yes or No

3.3 Data Analysis and Statistics

3.3.1 Descriptive Statistics

The data was initially recorded in Excel and then transferred to SPSS for detailed analysis. All statistical analysis was carried out in IBM SPSS Statistics version 29. Absent data was excluded from analysis.

Shapiro-Wilk test of normality was carried out on all continuous data. Quantitative data was summarised using means and standard deviations. For data that was not normally distributed, median values were given together with interquartile range, along with maximum and minimum values. Categorical data was summarised using percentages. Significance was set at $p < 0.05$.

3.3.2 Univariate Analysis

Each variable was considered separately in terms of its relationship with the incidence of repeat Dental General Anaesthetic. Normally distributed continuous data was analysed using independent-samples t-tests. Data that was not normally distributed was analysed using Mann-Whitney U tests. Chi square tests were used to explore the relationship between categorical variables and the two groups.

3.3.3 Logistic Regression Modelling

To adjust for confounders a multivariable logistic regression model was used to further investigate the interaction of the variables and their impact of the study and control groups. The outcome variable for the model was study or control group.

3.4 Results of the Case Control Study

The results of the case control study will now be presented. Demographic and patient characteristics of the two groups will be presented first, followed by a summary of available data and subsequent normality tests.

3.4.1 Demographics of groups

3.4.1.1 Number of Participants

A total of 6012 DGA episodes were identified. 298 patient records were initially identified for inclusion in the repeat DGA study group. 23 of these patient records had incorrectly been allocated a DGA code twice at the initial DGA episode. These patients were moved and correctly reallocated to the single DGA group, with 275 patients included in the repeat DGA group. A total of 5427 patients were identified for the control group. This is shown in Table 3.1.

A random number generator was used to match the number of patients in the study group to the number of patients identified for inclusion in the control group (275 patients). Patients were not matched on other variables or characteristics, as these variables were investigated as part of the Case Control study.

Table 3.1 Numbers of Children Included in The Case Control Study

	Inclusion criteria met	Data unavailable	Total
Study (Repeat DGA) Group	298	23	275
Control (Single DGA) Group	5427	0	275

3.4.1.2 Age

Age of patients at the time of the DGA was recorded (Table 3.2). There was a significant difference between groups according to Mann Whitney U test, U = 28606.500, p = <0.001. This suggests the younger the child at DGA1, the increased likelihood of repeat DGA.

Table 3.2 Mean Age of Patient at First DGA (in Years)

Group	Number (N)	Mean	SD	Median (IQR)	Min	Max
Study Group	275	5.5	2.8	5 (3)	1	15
Control Group	275	6.7	3	6 (4)	1	16
Total	550					

N = Number

IQR = interquartile range

Min = Minimum

Max = Maximum

3.4.1.3 Gender

A summary of the gender distribution is shown in Table 3.3. Gender was fairly evenly distributed between the two groups, and there was no significant difference according to chi squared test (chi-square = 1.7, p = 0.19).

Table 3.3 Gender Distribution of Repeat and Single DGA Groups

	Repeat DGA (%)	Control (%)	Total (%)
Male	143 (52%)	158 (57%)	301 (55%)
Female	132 (48%)	117 (43%)	249 (45%)
Total	275 (100%)	275 (100%)	550 (100%)

3.4.1.4 Socioeconomic status

Postcode at the date of the DGA procedure was used to obtain a deprivation decile from the Index of Multiple Deprivation (IMD). No significant difference was noted between groups according to IMD decile (chi square = 10.2, p = 0.334). Deprivation deciles according to groups is shown in Table 3.4.

3.4.1.5 Medical history

Medical history records were used to determine the presence of a neurological co-morbidity as shown in table 3.5. These included conditions such as cerebral palsy, autism, global developmental delay, and genetic syndromes with a neurological component. Summary of these conditions is found in Appendix 5. Where more than one neurological condition was listed for the same patient (e.g., autism and global developmental delay), the condition listed as reason for the DGA was recorded as the primary neurological disability. A significant difference was noted between the control and single DGA group (chi-square 39.4, p = <0.001). This indicates children with a neurological comorbidity were significantly more likely to receive repeat DGAs.

Table 3.4 Distribution of IMD Deciles in Repeat and Single DGA Groups

IMD Decile	Group		Total Number (%)
	Repeat DGA	Single DGA	
1	17 (6.2)	10 (3.6)	27 (4.9)
2	12 (4.4)	9 (3.2)	21 (3.8)
3	34 (12.4)	25 (9.1)	59 (10.7)
4	24 (8.7)	20 (7.3)	44 (8)
5	32 (11.6)	24 (8.7)	56 (10.2)
6	32 (11.6)	34 (3.6)	66 (12)
7	28 (10.2)	37 (13.4)	65 (11.8)
8	40 (14.2)	38 (13.8)	78 (14.2)
9	29 (11)	38 (13.8)	67 (12.2)
10	27 (9.8)	40 (14.5)	67 (12.2)
Total	275 (100%)	275 (100%)	550 (100%)

IMD Decile = Index of Multiple Deprivation Decile

(1 – Most Deprived, 10 – Least Deprived).

DGA = Dental General Anaesthetic

Table 3.5 Neurological Disability Distribution Between Repeat and Single DGA Groups

Neurological deficit	Group		Total
	Repeat DGA (%)	Single DGA (%)	
No	184 (67%)	245 (89%)	429 (78%)
Yes	91 (33%)	30 (10%)	121 (22%)
Total	275 (100%)	275 (100%)	550 (100)

3.4.1.6 Social History

Social history records were used to determine the presence of any social history concerns or complexities presented by the patient, as shown in Table 3.6. These included the allocation of a social worker support, care orders, foster care and parental responsibility held by someone other than a parent. A summary of this is shown in Appendix 6.

There was no difference between the groups according to chi squared test (chi-square = 0.14, p = 0.69). The number of patients with social concerns was evenly distributed between the two groups.

3.4.1.7 Presentation of Acute Symptoms

The presence of acute symptoms was recorded for each patient in each group, as shown in Table 3.7. This included pain, swelling and/or the prescription of antibiotics. There was no significant difference (chi-square 1.4, p = 0.24). A summary of these symptoms is found in Appendix 4.

Table 3.6 Social History Risk Factors in Repeat and Single DGA Groups

Social History Risk Factors	Group		Total
	Repeat DGA (%)	Single DGA (%)	
No	242 (88%)	239 (87%)	481 (88%)
Yes	33 (12%)	36 (13%)	69 (12%)
Total	275 (100%)	275 (100%)	550 (100)

Table 3.7 Presentation of Acute Symptoms in Repeat and Single DGA Groups

Acute symptoms	Group		Total
	Repeat DGA (%)	Single DGA (%)	
No	105 (47%)	118 (53%)	223 (41%)
Yes	170 (52%)	156 (48%)	326 (59%)
Total	275 (100%)	275 (100%)	550 (100)

3.4.1.8 Attendance

The number of total appointments booked for each patient was recorded, along with the number of appointments that were attended, cancelled, and missed. This is shown in Table 3.8. A missed appointment is considered a Was Not Bought (WNB). The percentage of appointments that the patient WNB to was calculated from the total number of appointments booked.

In the study group, 30% of patients attended all appointments, and 70% were not bought to all appointments. The highest percentage of WNB appointments for a patient was 52%, with a median of 10% for the group. For the control group, 63% of all patients attended all appointments. The highest percentage of WNB appointments for a patient was 67%, with a median of 0% for the group. Mann-Whitney U test showed a significant difference between the groups in terms of the percentage of missed appointments ($U = 45005.5$, $P<0.01$).

Table 3.8 Mean and Median Booked Appointments that Patients Were Not Bought to in Repeat and Single DGA Groups

Group	WNB	Mean	SD	Median (IQR)	Min	Max
Repeat DGA	70%	11.4%	11.2	10% (19)	0%	52%
Single	37%	10.5%	16.2	0% (20)	0%	67%

SD = Standard Deviation

WNB = Was Not Bought

3.4.2 Dental Characteristics of the Groups

3.4.2.1 Pre-Operative Treatment

3.4.2.1.1 Radiographs

Pre-operative radiographs were noted for each patient in each group, as shown in Table 3.9. A significant difference between the groups according to the presence of pre-operative radiographs was found (chi square = 58.2, p = <0.001). Patients receiving more than one DGA were significantly less likely to have pre-operative radiographs than those receiving a single DGA.

3.4.2.1.2 Oral Health Advice

The provision of oral health advice including oral hygiene instruction and dietary advice was recorded for each patient (Table 3.10). If oral health advice had been recorded at any point during the patients current Course of Treatment, it was recorded. The difference in provision of oral health advice was found to be significant according to chi squared test (chi square = 12.3, p = <0.001).

3.4.2.2 Operative Treatment

3.4.2.2.1 Operator Grade

Operation notes were used to record the grade of the operator performing the dental treatment for each patient at each general anaesthetic. This distribution can be seen in Table 3.11. The difference between the operating practitioner grade for each group was found to be significant (chi square = 57.7, p = <0.001).

Table 3.9. Percentage of Patients who Received Pre-Operative Radiographs in the Repeat and Single DGA Groups.

Pre-op Radiographs	Group		
	Repeat DGA (%)	Single DGA (%)	Total
No	220 (80%)	134 (49%)	353 (64%)
Yes	55 (20%)	141 (51%)	196 (36%)
Total	275	275	550 (100%)

Table 3.10 Percentage Of Patients who Received Oral Hygiene Instruction in the Repeat and Single DGA Groups

Prevention advice	Group		Total
	Repeat DGA (%)	Single DGA (%)	
No	101 (37%)	142 (52%)	243 (44%)
Yes	174 (63%)	133 (48%)	307 (56%)
Total	275	275	550

3.4.2.2.2 Operative Radiographs

Radiographs taken during the operating procedure were recorded for each group, shown in Table 3.12. These were all taken in manual film form. The difference between the groups was not found to be significant (chi square = 4.9, p = 0.04). Very few radiographs were taken intraoperatively in both groups.

Table 3.11 Operator Grade for Repeat and Single DGA Groups

Operator Grade	Group		Total
	Repeat DGA	Single DGA	
Dental Core Trainee	16 (6%)	0	16 (3%)
Dental Officer	156 (57%)	231 (84%)	387 (70%)
Registrar	16 (6%)	2 (1%)	18 (3%)
Specialist in Paediatric Dentistry	45 (16%)	25 (9%)	70 (13%)
Paediatric Dentistry Consultant	42 (15%)	17 (6%)	59 11%)

Table 3.12 Operative Radiographs for Repeat and Single DGA Groups

Operative Radiographs	Group		Total
	Repeat DGA (%)	Single DGA (%)	
No	246 (90%)	259 (94%)	505 (92%)
Yes	29 (10%)	16 (6%)	45
Total	275	275	550

3.4.2.2.3 Number of Extractions

The number of extractions carried out during the general anaesthetic procedure was recorded for each patient (Table 3.12). This included both primary and permanent teeth. Across both groups of 275 patients, the number of extractions per group was 1654 for the Single DGA Group, and 1437 for the Repeat DGA Group, totalling 3091 extractions across 550 patient episodes. The data was not normally distributed. A significant difference was found using Mann Whitney U Test ($U = 32161.5$, $p = 0.02$).

3.4.2.2.4 Number of Restorations

The number of restorations completed for each patient was recorded, shown in Table 3.13. Only restorations that were classed as intervention were recorded. Those used as an ad-hoc or preventative measure, such as fluoride varnish, scale and polish, and fissure sealants were not recorded.

The number of restorations was analysed for each group using Mann Whitney U test and the distribution of data was not normal. The difference was found to be significant (U = 42002.5, p = <0.001). Mean and median number of restorations are summarised in Table 3.14.

Table 3.12 Mean, Median and Total Number of Extractions Per Patient in Repeat and Single DGA Groups

Group	Extractions Per Patient					Total number of patients
	Mean	SD	Median (IQR)	Minimum	Maximum	
Single DGA	6	3.3	6 (4)	0	20	1654
Repeat DGA	5	3.4	4 (6)	0	20	1437

Table 3.13 Mean, Median and Total Number of Restorations Per Patient in the Repeat and Single DGA Groups

Group	Restorations Per Patient					Total number of patients
	Mean	SD	Median (IQR)	Minimum	Maximum	
Single DGA	0.3	1.1	0 (0)	0	11	88
Repeat DGA	0.9	1.9	0 (o)	0	12	235

3.4.2.3 Post-Operative Treatment

3.4.2.3.1 Follow-up Plan

Plan for follow-up was documented for each patient. Patients were either reviewed within the Salaried Dental Service or discharged back to the General Dental Practitioner, as shown in Table 3.14. Chi square test demonstrated a difference between the groups (chi square = 20.888, p = <0.01).

Table 3.14 Follow-up Appointments for Repeat and Single DGA Groups

Salaried Dental Service Review	Group		Total
	Repeat DGA (%)	Single DGA (%)	
No	194 (71%)	238 (87%)	432 (79%)
Yes	81 (29%)	37 (13%)	118 (21%)
Total number of patients	275 (100%)	275 (100%)	(100%)

SDS = Salaried Dental Service

DGA = Dental General Anaesthetic

3.4.3 Summary of Data Collected

3.4.3.1 Normality Tests

All continuous variables in the study were tested for normality using Shapiro-Wilks normality test. A summary in shown in Table 3.15. Results of the normality tests dictated the use of parametric or non-parametric statistics.

Table 3.15 Results of the Shapiro-Wilk Test for Normality

Variable	Shapiro-Wilk			Test
	Statistic	dF	Sig.	
Age	0.926	550	<0.01	Non-parametric
Attendance	0.794	550	<0.01	Non-parametric
Number of restorations	0.432	550	<0.01	Non-parametric
Number of extractions	0.940	550	<0.01	Non-parametric

Df = degrees of freedom

3.4.3.2 Univariate Analysis

Summaries of all the univariate analyses carried out on children in the study are shown in tables 3.16 and 3.17.

Table 3.16 Summary of Descriptive Statistics for all Continuous, Non-Normally Distributed Variables

Variable	Single Group			Repeat Group			P
	Mean	Med (IQR)	Range	Mean	Med (IQR)	Range	
Age	6.7	6	16	5.5	5	15	<0.01
WNB %	10.5	0 (20)	67%	11.4%	19	52%	<0.01
Number of Restorations	0.3	0 (0)	11	0.9	(0)	11	<0.01
Number of Extractions	6	6 (4)	20	5	4 (6)	20	<0.01

IQR = Interquartile range

P = p value according to Mann-Whitney U Test

Table 3.17 Summary of Descriptive Statistics for all Categorical Variables

Variable	Repeat Group		Single Group		P
	Odds ratio	95% CI	Odds ratio	95% CI	
Gender (F)	0.896	0.94 – 1.3	1.117	0.9 – 1.3	0.19
Neurological comorbidity	0.570	0.4 – 0.6	2.303	1.6 – 3.1	<0.001
Social factors	1.052	0.8 – 1.3	0.952	0.7 – 1.2	0.69
Acute symptoms	0.903	0.7 – 1.0	1.106	0.9 – 1.3	0.244
Pre-operative radiographs	2.21	1.7 – 2.8	0.528	0.4 – 0.6	<0.001
Prevention	0.733	1.6 – 0.8	1.349	1.1 – 1.5	<0.001
Operative radiographs	0.756	0.5 – 0.9	1.1442	0.9 – 2.1	0.043
Follow-up in SDS	0.645	0.5 – 0.7	1.757	1.3 – 2.3	<0.001

P = p value according to Chi Square Test

IMD Decile = index of Multiple Deprivation Decile

F = Female

SDS – Salaried Dental Service

3.4.3.3 Multivariable Logistic Regression

The construction and results of the logistic regression model are now described. Factors were entered by forward selection. Goodness of fit was checked by reference to the NagelKerke R square value. Odds ratios were expressed for the repeat DGA group relative to the single DGA group.

The univariate analysis indicated that several variables had a significant impact. These were patient age, neurological deficit, attendance, pre-operative radiographs, number of extractions and restorations, operator grade, prevention advice and follow-up plan. These variables were input into the multivariable regression analysis, shown in table 3.18. Operator Grade was not included in the regression analysis, as the operator is often pre-selected dependant on the patients' medical history and treatment need.

The logistic regression was performed to ascertain the effects of age, was not bought percentage, number of restorations, number of extractions, neurological factor, and oral hygiene advice on the likelihood that patients require a second DGA. The logistic regression model was statistically significant, p = <0.001. The model explained 33.9% (NagelKerke R^2) of the variance in DGA rate and correctly classified 73.3% of cases.

Females were 1.5 times more likely to receive a repeat DGA than males. Patients with a neurological condition were 4.3 times more likely to receive more than one DGA. Patients given prevention advice, and those receiving more restorations at the first DGA were also more likely to receive a DGA2. Increases in age and number of extractions at DGA1 was associated with a reduced likelihood of a repeat DGA. The older the patient at the first DGA, and the more extractions they received were both associated with a reduced likelihood of a DGA2. Age, number of extractions all remained statistically significant. Gender, number of extractions, percentage of WNBs and prevention advice provision all became non-significant.

Table 3.18 Multivariable Regression Analysis

Variable	B	Wald	df	p value	Exp(B) (Odds Ratio)	95% CI for EXP(B)	
						Lower	Upper
Age	-.177	19.387	1	<.001	.840	.777	.908
Female	.513	6.307	1	.012	1.673	1.120	2.500
% WNB	.235	.101	1	.751	1.264	.297	5.389
Pre-op radiographs	-1.274	29.368	1	<0.001	.280	0.176	0.443
No of Restorations	.118	2.184	1	.139	1.125	.962	1.316
No of Extractions	-.090	9.168	1	<.001	.914	.862	.969
Neurological condition	1.118	24.343	1	<.001	3.059	1.715	5.455
Prevention Advice given	.651	8.689	1	.003	1.917	1.244	2.945
Follow Up (1)	0.326	1.252	1	0.263	1.386	0.783	2.453

% WNB = Percentage of appointments patient was not bought to

B = regression coefficient

dF = degrees of freedom

CI = Confidence Interval

3.5 Summary of Results of the Case Control Study

1. Females were more likely to receive a DGA2 than males, but this was not significant.
2. Patients with neurological co-morbidity were significantly more likely to receive a DGA2
3. Patients who received a higher number of restorations at DGA1 were more likely to require a DGA2
4. Patients who received a higher number of extractions at DGA1 were less likely to require a DGA2
5. Patients who received Oral Health Advice had increased likelihood of a DGA2
6. The older the patient was at DGA1 reduced the likelihood of a DGA2
7. The presence of operative radiographs does not affect the likelihood of a DGA2
8. Most patients were treated by a Senior Dental Officer
9. Patients were more likely to be treated by a Specialist or a Consultant in Paediatric Dentistry at DGA2
10. Patients receiving a DGA2 were less likely to have pre-operative radiographs available
11. Patients who were not bought to all appointments were significantly more likely to receive a DGA2
12. The younger the age of the child at the first DGA increased the likelihood of a DGA2
13. Patients with a complex social history were significantly more likely to require a DGA2
14. The presence of pre-operative complications such as pain and swelling did not affect the likelihood of a DGA2

3.6 Discussion of the Case Control Study

The discussion of the case control study is divided into two parts. The first part examines the methodology. The second part discusses the results and findings.

3.6.1 Introduction

Dental General Anaesthesia is routine procedure provided by the NHS. The majority of DGA procedures are carried out to treat dental caries, which is considered a primarily preventable disease (2). Most studies have demonstrated very low rates of repeat DGA, where a child has required more than one DGA in childhood. However, studies vary significantly in the length of time they have analysed data for, and what is a 'repeat' DGA. One way of addressing this issue was to examine all the children who received a repeat DGA since the implementation of the electronic database, allowing the longest frame of time possible to collect data from. Additionally, recording all the repeat DGAs regardless of length of time in between DGA1 and DGA2 ensured no data was missed.

3.6.2 Discussion of Methodology for the Case Control Study

3.6.2.1 Site Selection

The Chief Investigator (CI) was working in the North Yorkshire Salaried Dental Services at the time of this study. There are 11 dental clinics that come under this remit, and three hospitals in which the DGA is carried out. Data from all 11 clinics was collected, as this would give the largest data capture and most accurate representation of the population.

The CI worked primarily in the Harrogate clinic. For this reason, Harrogate was chosen as the CI's base for data collection. All electronic patient records for patients treated within the North Yorkshire Salaried Dental Service could be accessed, as all clinics used the same patient software. This eliminated the need to travel to different sites.

3.6.2.2 Study Design

The study was a retrospective case control study, with an epidemiology aspect to it. This was chosen for several reasons. Firstly, the amount of retrospective data available on the electronic database was large and had the potential to yield useful results. Secondly, as it is not possible to randomise patients to certain groups given the nature of the study, retrospective analysis was deemed acceptable.

3.6.2.3 Data Collection

The possibility of using written notes in combination with electronic records was considered by the CI. Paper notes were still used by some clinicians following introduction of the electronic database to record additional information, in addition to electronic notes. The use of paper records declined significantly and was not uniform throughout the service. The CI reviewed a sample of paper notes and found they did not add additional information required for data collection, as recording of DGA specifics such as the DGA episode, date, treatment, and follow-up plan were always a mandatory part of the electronic patient record. Furthermore, paper notes were only accessible in Harrogate and Northallerton clinics. All other clinics stored paper notes in external storage facility.

For this reason, electronic database records were chosen. Although this limited the data to the time at which the electronic database was established, it increased validity of the data. The electronic database had been used for 16 years up to 2018, so available data was still extensive. Data was therefore collected from patients who received their treatment between January 2002 and May 2018.

After all patients that met inclusion criteria were identified, the data was analysed. 298 patients were identified for the study (repeat DGA) group. It was found that 23 patients were allocated an incorrect DGA code, when they had only received one DGA or were

reported to have received an DGA in a previous service. For this reason, these patients were not included in the study. 5427 patients were identified for the control (single DGA) group. All relevant information was available, and all were included in the study. This is largely due to the electronic database function, in which the record cannot be marked as complete until certain fields have been filled in.

The decision on which factors to include in the data collection was taken after discussion with research supervisors, knowledgeable consultants, and careful review of the literature. No attempt was made to contact patients, parents, or clinicians to clarify missing information.

In addition to the variables collected in the final data sheet (Figure 3.1), they considered collecting detailed data regarding tooth restorations. This included type of material, surface, and whether it was subsequently extracted. However, data regarding the position and material used to restore teeth was limited on the electronic database. The database uses a basic charting system, and for ease of use, most clinicians only recorded whether the tooth was restored or extracted. Details of the restoration would have been recorded in the paper notes, with a more detailed hand-written dental chart.

Furthermore, as paper notes were only available at 2 out of the 11 dental clinics, details of restorations were not explored further. Doing so would have limited the sample by eliminating most dental clinics and may have introduced bias by eliminating data from that group (children living in those areas).

3.6.2.4 Selection of Participants

The study group consisted of children who received more than one DGA within the North Yorkshire Salaried Dental Service. The control group consisted of children who had received a single DGA within the service. For both groups, all DGAs had to have

occurred between January 2002 and May 2018, to be picked up on the database. Identification of DGAs was completed through a search function on the electronic database. No patient was recruited through recall or written notes. If there was any doubt that the patient had received correct coding, the electronic notes were analysed further to confirm.

If there was an indication in the electronic notes that the patient had received a DGA elsewhere or outside of the timeframe, patients were excluded due to lack of data regarding the DGA. A small number of patients in the study group were excluded for this reason.

To reduce the chance of a patient in the control group having either received a previous DGA or would go on to receive a DGA in future, the timeframe was limited.

For the control group, although data was available from 2002 to 2018, they were considered for inclusion only if they received their DGA from 2008 to 2012. From this timeframe, they were selected using a random number generator. The decision to do this was agreed with research supervisors. This was done to minimise the potential for a previous or subsequent DGAs. If the patient had received another DGA, this would most likely have occurred within the six years before or after the identified DGA (38,54), assuming the patient hadn’t moved house to different area.

If patients in the control group received their DGA towards the earlier or later period of data collection, there is no way of knowing if they had received or would go on to receive further DGAs, therefore should have been excluded from the control group.

Patients in the study group were selected based on the inclusion criteria. All 275 suitable patients were included in the study. 275 patients were then chosen at random from

those matching inclusion criteria for the control group. They were chosen using a random number generator and patient ID numbers.

Patients in the control and study groups were similar in their age, gender, geographical locations, and history of at least one DGA. By matching the number of patients from the control and study groups, this enabled a comparison of outcomes among control and study groups to estimate the effect of number of DGAs, whilst reducing bias due to confounding.

One limitation of this study, although not in all areas, is the timespan of the data. Although this allowed for extensive data collection and increased the possibility of truly identifying all single and repeat DGAs, it also allowed for confounders in the form of outliers. For example, an average number of years between DGA1 and DGA2 has been reported, but there were of course outliers within this that contributed to the average. Outliers may have received repeat DGA a number of years after the first for reasons other than caries, such as dental anomalies.

3.6.2.5 Patient Confidentiality

A member of staff working at Cornlands Road Dental Clinic was known as the ‘Master User’ for the service. This person was trained to extract patient data from the electronic database and had enhanced access rights. The Master User is the only clinician within the service with advanced access to the patient database, allowing them to search for multiple parameters.

The master user generated a list of patients that met the inclusion criteria and provided these in the form of patient ID codes. From then on, they were not involved in the study.

The chief investigator (CI) was the only person to search the patient details using the case ID numbers. No patients were searched for using names. Once the CI had

recorded relevant information in the data collection sheet, patients were assigned numerical values to replace the ID number, and the search history was deleted.

Following this, the data were entered onto an excel spread sheet, prior to entry into SPSS. The patients age at general anaesthetic was calculated using date of birth from the data collection sheet. The date of birth was not entered into the excel spread sheet. The postcode collected on the data collection sheet was used to calculate the IMD Decile and was not entered into the excel spreadsheet. All data collection sheets were shredded and placed in confidential waste bins.

Data was stored on an encrypted memory stick that provided by the IT team at Harrogate District Hospital. This memory stick was kept in a locked drawer, in a keycode-protected office safely within the Harrogate clinic.

3.6.2.6 Statistical Analysis

Most data collected was not normally distributed as demonstrated by Shapiro-Wilk tests. Although descriptors quote medians, minimums, and maximums they also quoted means and standard deviations to allow broader comparison with other studies. The univariate analysis used Mann-Whitney U test and independent t-tests.

The initial analysis of the case control study was univariate analysis to identify possible influencing factors. A multivariable logistic regression model was then used to determine if the significant variables are related. The technique used was forward selection. The outcome variable was the group. Collinearity of variables was assessed using Variance Inflation Factor (VIF). All VIF values were over less than 1.5, indicating a small degree of collinearity.

3.6.2.6.1 Conflict of Interest

There was no conflict of interest in this study.

3.6.3 Discussion of the Case Control Results

3.6.3.1 Patient Demographics

3.6.3.1.1 Age

The average of a child that went to have a repeat DGA was 5.5 years old, compared to 6.7 years old in children that received a single DGA. This is comparable to similar studies (Jogezai et al, 2014; Harrison and Nutting, 2000) who reported an average age of 5.3 years and 5.8 years respectively. Other similar studies have reported slightly higher average ages at 6.5 years, 6.3 years, and 6.2 years respectively (Albadri et al, 2006, Savanheimo and Vehkalahti, 2014; Kakaounaki et al, 2010) with age at the first DGA episode around the 5–6-year age bracket.

This finding is likely due to several factors. Firstly, the younger a child is, the greater the length of time they have to develop further dental problems that require a subsequent DGA. Secondly, younger children are more likely to require a DGA than older children due to their ability to tolerate treatment, and available treatment options (Baghdadi et al, 2021). Furthermore, additional treatment options are available to older children that are not suitable for those of a young age. A child aged 6 and above may be offered inhalation sedation as an alternative to DGA, but this is rarely suitable for younger children (RCS England, 2020).

In addition to this, the carious process can begin as soon as a tooth erupts, in the primary and permanent dentitions and can therefore affect children as early as teeth erupt, age 6-months and onwards. However, other dental problems such as dental anomalies or surgical extractions are most likely to be diagnosed following development

of the permanent dentition. They are often treated in the late mixed dentition, or early permanent dentition to allow the remaining teeth to erupt and ensure no further issues. Therefore, children who have not had previous experience of caries may still require a DGA for non-carious dental problems, and this would inevitably mean the child older when these problems are recognised and treated (Haworth et al, 2017).

Finally, several guidelines exist regarding extraction of first permanent molars (FPM) of poor prognosis (Noar et al, 2020). Although not reported in statistical analysis, the chief investigator noted that the majority of DGA2 episodes received extraction of at least one FPM. FPM often erupt around age 6-7, and therefore it is reasonable to assume they had not erupted in most children in the repeat group at the DGA1 (as they were found to be on average 5.5 years old) but may have erupted in those in the single DGA group (as they were found to be on average 6.7 years old) (Worthen and Mueller, 2000).

For example, one study found that at least 20% of patients receiving DGA1 prior to the eruption of FPM were more likely to receive a DGA2 within 1 year (Foster et al, 2006). A number of studies have shown high incidence of caries in FPM increasing with age, with 40.2%, 66.4% and 75.5% among 6-7, 7-10 and 9-12 years old respectively (NHS England, 2013).

3.6.3.1.2 Gender

Although the Case Control Study did not match for gender, an almost equal number of males and females was found in both groups. No significant difference was found. This helps to improve the efficiency and quality of the study. None of the studies into repeat DGA found gender to be significant (Maes et al, 2022; Bucher et al, 2016; Guidry et al, 2017) and all reported very similar male: female ratios.

This finding is curious, as previous studies examining gender and caries rates generally report high rates of caries in females. However, these findings are often reported for adults, rather than children, and are based on ethnic cultures where women are responsible for food preparation. The main reasons suggested for an increase in caries rates in women compared to men are pregnancy, increased availability of food and snacking habits due to food preparation and earlier eruption of teeth (Lukacs and Largaespada, 2006).

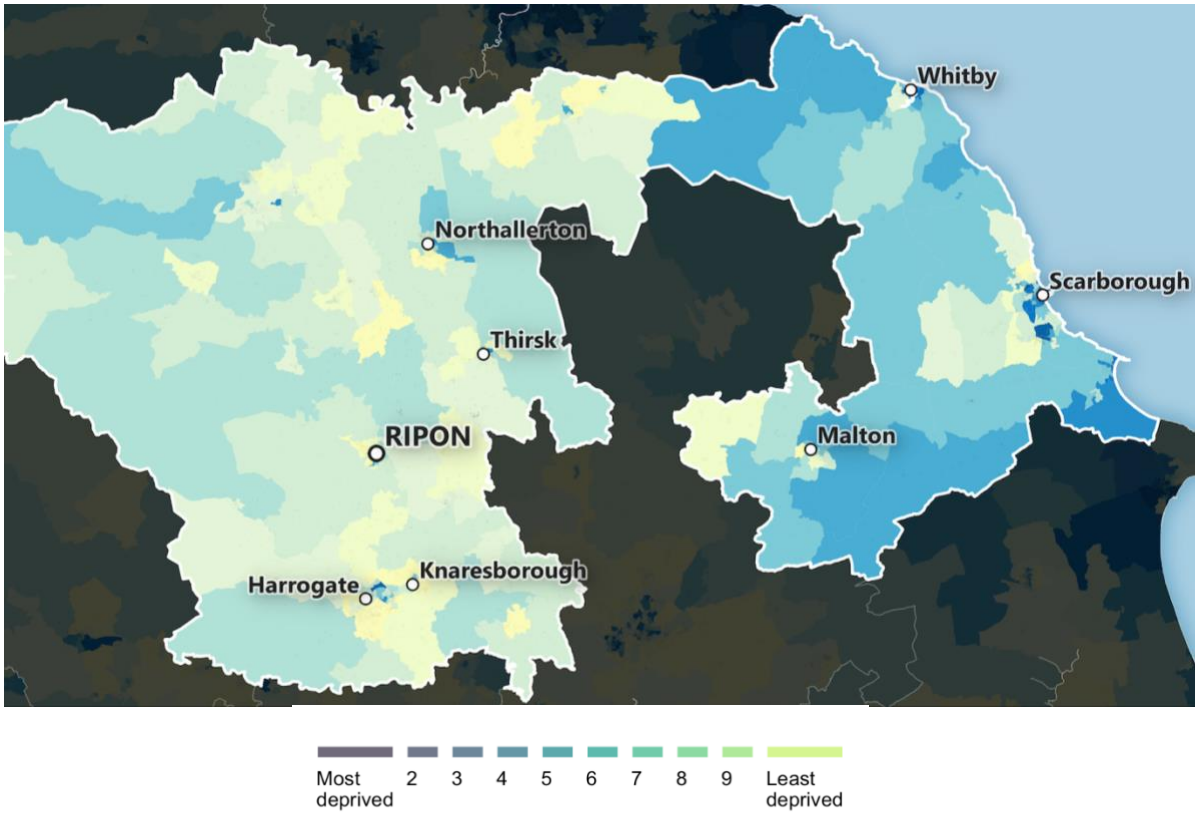
3.6.3.1.3 Socioeconomic Status

There was no difference between groups for IMD decile according to chi square test. 56.8% of repeat DGA patients and 59.1% of single DGA patients lived into 50% of the least deprived areas. This is surprising as the majority of DGAs are to treat dental caries which has a socioeconomic predilection.

One explanation for this could be the size of the geographical area studied, North Yorkshire. North Yorkshire is the largest county in the UK and includes some of the most and least deprived postcodes (shown in Figure 3.2). It may be that the population IMD is too broad to identify any difference. Furthermore, as children in the control group were selected at random, this gave all patients the same chance of being included in the study, regardless of IMD.

Very few studies have compared the level of deprivation in single and repeat DGA groups. As discussed in the epidemiology study of this thesis, patients who received more than one DGA were more likely to live in socially deprived areas, although this was not compared to a control group (Goodwin et al, 2015).

Figure 3.2 The County of North Yorkshire Represented According to Index of Multiple Deprivation Index (mySociety, 2019).



3.6.3.1.4 Medical History

The presence of neurological factors was found to be a significant risk factors for the occurrence of repeat DGA in the study. Regression analysis found the Exp(B) value was large, suggesting patients with a neurological factor were 4.305 times more likely to receive a repeat DGA.

This finding is consistent with many other studies, with Kakaounaki et al (2010) reporting 71% of their patient receiving repeat DGAs had a significant medical history. Guidry et al (2017) found that patients aged 1 to 12 with medical co-morbidities were 4 times more likely to require a DGA2 than fit and healthy subjects, whilst Bucher et al (2016) reported 40% of children found to receive a DGA2 and DGA3 had a congenital or chromosomal anomaly.

The conditions commonly reported in this study were autism, developmental delay, global developmental delay, learning difficulties, genetic syndromes with a neurological component, chromosome deletions and cerebral palsy (summarised in appendix 2.1).

Similar studies report global development delay was the most prevalent comorbidity in children (Guidry et al, 2017). Tahmassebi et al (2014) found the most common medical conditions out of 129 children undergoing DGA were respiratory disorders (40/129) followed by cardiac (19/129) and neurological disorders (18/129).

One explanation for this is that children with neurological disorders often find it difficult to tolerate dental treatment for several reasons. They may not be able to understand what is happening, increasing fear and anxiety, or be able to verbalise their concerns. They may be unable to sit unaided or prevent involuntary movements. Furthermore, children with developmental disabilities are more likely to experience dental decay due to difficulty maintaining oral hygiene, difficulty accessing dental care and feeding issues (Kakaounaki et al, 2010).

These findings suggest patients with neurological difficulties should receive comprehensive dental care and routine dental care within a more experienced team, such as the Salaried Dental Services. Routine dental care should be completed by a Specialist in Paediatric Dentistry due to their increased risk and need for thorough and expert care. The Paediatric Dentistry Commissioning Guide has tried address this and improve access to care for high risk and medically compromised children. It is important these efforts are continued (NHS England, 2018).

3.6.3.1.5 Social History

Social history complexities were not found to be significant between the groups. The factors examined included the presence of a social worker, children in foster care and children living with someone other than a parent (summarised in appendix 2.2). Both groups presented similar results, with 12% and 13% having some form of social issue in the repeat DGA and single DGA group respectively.

This finding is surprising, as it generally considered that children with a more complex social situation are more likely to suffer from dental caries, and therefore DGA. Looked after children are known to have increased and often unmet health needs and may face difficulties accessing healthcare services (104). One study of children receiving DGA found parents who did not bring their children to the dentist regularly reported feeling overwhelmed with the tasks of daily life and these took priority over dental appointments (Sarri et al, 2012). These parents were more likely to be unemployed and report a dysfunctional home life.

Children from low-income families are also more likely to experience decay than those from higher income families who do not receive additional financial support (61). Furthermore, children with complex social situations are generally less likely to see a dentist unless in pain (NHS England, 2013). One epidemiological study reported dental neglect prevalence between 40 and 50% in 15–16-year-olds at secondary schools in a deprived inner-city area (Sarri et al, 2012).

Dental neglect is defined as ‘the persistent failure to meet a child’s basic oral health needs, likely to result in the serious impairment of a child’s oral or general health or development’ by the British Dental Association. It may occur in isolation but is often an indicator of a wider picture of child maltreatment, which is more likely to occur in socially deprived families (Harris et al, 2006).

A survey of General Practitioners in the UK worryingly found that 84% were not confident in recognising dental neglect and 56% did not think repeat DGA was a concern. Furthermore, of those with suspicions of dental neglect, 32% did not complete an onwards referral (Welbury et al, 2003). The National Institute for Health and Care Excellence (NICE) does in fact recognise repeat DGA as a feature of concern for dental neglect (NICE, 2015). This therefore suggests GDPs and the wider dental team need further training on recognition of dental neglect and how to treat appropriately.

3.6.3.1.6 Presentation of Symptoms

In this study, the presence of acute symptoms at DGA1 was high in both the control and study groups, ranging from 50% - 90% depending on the total number of DGAs received. There was no significant difference between children receiving a single or repeat DGA. This would therefore suggest that children needing a single DGA in their lifetime are just as likely to report acute symptoms as those who require multiple DGAs.

This indicates that a child complaining of pain is not always motivating enough to incentivise parental behaviour change and opinions towards oral health. Parents do report feelings of guilt following their child's DGA and the desire to improve preventative practices, but improvements have been found to be short-term (Kay and Blinkhorn, 1989; Baghdadi et al, 2021; Morgan et al, 2016). An improvement to this study would be to investigate whether the DGA did motivate parents to improve oral health behaviours, and the child's future dental treatment needs.

3.6.3.1.7 Attendance

The univariate analysis found the mean percentage of WNB (was not brought) appointments was significantly higher (11.4%) in the repeat DGA group compared to the single DGA group (10.5%). However, this was not significant in the multivariate analysis. In both groups, most children were not brought to at least one appointment, with high

total WNB percentages at 67% and 52% of appointments in the single and repeat DGA groups.

There were no studies that directly compared attendance in repeat DGA groups to single DGA groups, but many did report the same general findings. Many repeat DGA patients had a history of irregular attendance (Kakaounaki et al, 2006), failed to attend follow-up appointments (Leagault et al, 1972), and only attended the dentist when in pain (Landes and Bradnock, 1996).

This suggests that attendance is unreliable in repeat DGA groups, but it is not clear how this compares to attendance in single DGA groups as there was no significant difference when comparing multiple variables. Therefore, it is likely that attendance in all children receiving DGA (single and repeat DGAs) is unreliable, and every effort should be made to improve this.

3.6.3.2 Pre-operative Treatment

3.6.3.2.1 Radiographs

Univariate analysis found children receiving a single DGA were significantly more likely to have had pre-operative radiographs taken than those receiving repeat DGAs. Those with preoperative radiographs were 1.7 times less likely to receive repeat DGAs.

Albadri et al (2006) reported similar findings. Radiographs were available as part of the assessment process for 84 (34·3%) of the 245 patients who had had a single episode of GA. However, of the 33 patients who had had a repeat GA, only seven (21·2%) had radiographs available at the time of the initial GA (Albadri et al, 2006).

This reliability of this finding is uncertain, and the obvious confounder is medical history. Children with neurological difficulties are more likely to receive repeat DGA and are less

likely to be able to tolerate pre-operative radiographs. However, looking closely at the results of our study, 67% of the repeat DGA group did not have neurological difficulties, yet only 20% had pre-operative radiographs. This does not compare with the single DGA group, of which over half received pre-operative radiographs, and 10% had neurological difficulties.

Similar findings were reported by Young et al. (2009). Only 12% of patients referred for DGA had radiographs taken pre-operatively. However, the patients that did had radiographs were significantly more likely to have been referred from the community dental service than those referred from general dental practice (9.3% versus 36.9%; p=0.003, chi-squared test) (Geddis-Regan et al, 2022). These findings suggest that even within the Community Dental Services, with more experienced clinicians, radiographs are not routinely taken.

Therefore, it is reasonable to draw the conclusion that the number of patients should have received pre-operative radiographs. Intra-oral radiographs are key in diagnosing caries, and without visualisation of the interproximal surfaces, the examination cannot be 100% reliable (Foster et al, 2006).

3.6.3.2.2 Oral Hygiene Advice

Surprisingly, a significant difference was found in prevention advice given, with the repeat DGA group more 1.9 times more likely to receive prevention advice. This suggests that either the oral hygiene advice was not followed, or these patients had additional risk factors that prompted the dentist to provide OHI.

There were no comparative studies that examined provision of oral hygiene advice in single and repeat DGA groups. One reason for this could be the difficulty in assessing the uptake and implementation of this advice, and also the assumption that OHI had

been provided at some point in the patients journey. General Dental Practitioners are expected to provide OHI in patients at increased risk of caries development (32) but given the limited time many GDPs have to spend with patients, it is unlikely that all will receive thorough and personalised advice (Thomas et al, 2004).

The success of OHI in changing behaviours is debateable, and not guaranteed. A 2017 systematic review found that most studies examining the effects of oral healthcare prevention advice found no difference in early childhood caries reduction. They concluded that OHI in combination with other adjuncts such a fluoride varnish may be more useful (Xiao et al, 2019).

3.6.3.3 Operative Treatment

3.6.3.3.1 Operator Grade

One of the factors examined in this study was the role of the operator performing the extractions. 31% of repeat DGA operations being performed by specialist or consultants in paediatric dentistry, compared to 15% of single DGAs. Although this was found to be significant, it is unlikely to be a reliable factor. Patients are more likely to be treated by a specialist or consultant where there is complex treatment plan or medical history. Dental Officers and Senior Dental Officers (SDOs), although experienced, do not have specific training in managing children complex medical and dental issues.

In the UK, the majority of DGAs are performed by dental officers and senior dental officers. This is due to workforce planning, and the fact that there are significantly more SDOs than specialists and consultants (Graves et al, 2004). These finding suggest that we require more specialists and consultants to assess and treat patients with more complex treatment plans, in order to potentially reduce the number of repeat DGAs.

3.6.3.3.2 Operative Radiographs

Operative radiographs were low in both groups, with only 10% of the repeat DGA group, and 6% of the single DGA group having operative radiographs. No significance was found. This finding compared to pre-operative findings is surprising, as almost 50% of patients in the single DGA group received them. This would suggest that most children in the repeat DGA group received no radiographs at all.

This finding is concerning. There is indisputable evidence to support the value of bitewing radiographs in caries diagnosis (69). Notably, the use of bitewing radiographs has been found to increase the number of approximal lesions detected (compared to clinical examination alone) by a factor of between two and eight, and that 50% of carious lesions would have been missed without bitewing radiographs (Kidd and Pitts, 1990).

Kirby et al found radiographs were available for 53% of their DGA group pre-operatively. The majority of those (79%) who did not have radiographs available were then listed for comprehensive care, in which radiographs could be taken under DGA if needed (Kirby et al, 2020).

However, comprehensive care is not available in all hospitals, and there are challenges in terms of radiographic assessments during DGA procedures. Methods of taking operative radiographs under DGA varies between hospitals. Some do not have access to radiographic equipment whilst others limit them to complex cases only. Further issues arise when considering the time taken to process and report radiographs, all whilst the patient is under anaesthesia.

Guidelines exist in special care dentistry, that all adults should receive all relevant intra-oral radiographs if it has not been possible pre-operatively (Geddis-Regan et al, 2022).

These are suggested in paediatric dentistry guidelines but not an absolute requirement (Adewale et al, 2011). More clarification is required and availability of comprehensive treatment under DGA if all necessary radiographs are to be completed.

3.6.3.3.3 Number of Extractions and Restorations

Children in the repeat DGA group were significantly less likely to receive extractions at their DGA1 than children in the single DGA group. They were also significantly more likely to receive restorations at their DGA1 than the single DGA group. The number of extractions remained significant in the multivariable analysis, although restorations did not. Several factors are likely to be involved. These findings are similar to those reported by Albadri et al (2006). In their study, the mean number of extractions in the single DGA group was 4.6 compared a mean of 3.2 in the repeat DGA group at DGA1. This difference was significant.

Children in the repeat DGA group were generally younger and also more likely to have a neurological medical factor. Subsequently, patients with a neurological factor are more likely to be considered for comprehensive care, that includes restorations, as they have additional factors that increase their caries risk. The younger the child, the more likely a dentist is to attempt to restore primary teeth rather than extracting them very young (Amin et al, 2010).

Furthermore, children in the repeat DGA group were less likely to have pre-operative or operative radiographs, and therefore a number of carious lesions may have been missed, leading to fewer extractions at DGA1. Kidd and Pitts (1990) reported 50% of carious lesions in primary teeth were missed with clinical examination alone.

As discussed above, comprehensive dental care is not available at within all services and is often limited to patients with additional needs. Goodwin et al (2015) examined

provision of DGA across six hospitals in Wales. Only one of these hospitals had the resources to provide restorations as well as extractions.

Another limitation is the lack of specifics in terms of teeth extracted and restored. Identification of restored teeth at DGA1 that were extracted at subsequent DGAs, or sound teeth at DGA1 that had developed caries at DGA2 may have provided useful information in terms of rate of caries development and restoration success.

3.6.3.4 Post-Operative Treatment

3.6.3.4.1 Follow-up Plan

Patients who received a repeat DGA were significantly more likely to be followed-up within the service providing the DGA, than those who received a single DGA. Those who received a single DGA were more likely to be discharged back to the referring dentist for ongoing care.

This finding is to be expected, as children receiving repeat DGAs were more likely to be medically compromised and these patients would generally be expected to receive care within the Salaried Dental Services. However, as the univariate analysis reported that repeat DGA patients were significantly more likely to fail to attend appointments, it would have been more useful to record the number of follow-up appointments that were attended, rather than just the provision of an appointment. Furthermore, some patients will have initially been referred to the SDS and then retained as a patient due to additional needs. This was not recorded and would have been useful to give an accurate representation of the patients that receive long-term care within the SDS and go on to received subsequent DGAs.

3.6.4 Summary of the Case Control Discussion

The majority of children who present for dental treatment under general anaesthesia (DGA) are between 5 and 7 years old. This study indicated that the younger a child is at DGA, the more likely they are to receive repeat DGA in future. Children who received a single DGA were significantly older at DGA1 than children who received repeat DGA. This finding was supported by similar studies and can be explained by a number of reasons. Younger children may find routine dental treatment with local anaesthetic more challenging, may be more resistant to tooth brushing and it also allows a greater length of time for caries to develop.

There appears to be no significant difference with regards to gender and single or repeat DGA experience. Similar studies also found no significant difference.

Children in this study lived within the large geographical area of North Yorkshire, which consists of some of the most and least deprived areas in England. No significant difference was found between children receiving a single DGA episode, and those receiving repeat DGA. This is surprising as the majority of DGAs are to treat dental caries which has a socioeconomic predilection.

Children receiving repeat DGA were 4 times more likely to have a neurological disability than those who received a single DGA. This strongly indicates the need for rigorous and meticulous treatment planning and oral health promotion in these patients, who may find dental treatment difficult for a number of reasons.

Social history concerns were not as significant as medical comorbidities, and there was no difference between the groups and social challenges. It would be beneficial to know the average number of children with complex social histories in the general population,

to determine if this compares to the average of 12.5% of children in single and repeat DGA groups.

Acute symptoms were reported in a large number of patients across both the single and repeat DGA groups. There was no significant difference. With between 50-90% of patients in both groups complaining of pain and swelling, this is concerning and highlights the need for drastic improvements in dental care across the country to prevent unnecessary suffering.

Most child were not brought to at least one planned appointment. Univariate analysis found this to be significant, with children in the repeat DGA group more likely to miss booked appointments than those in the single DGA group. Missed appointments cost the NHS significant amounts of money each year, and every effort should be made to encourage patients to attend. These include reminder phone calls, text messages and incentives.

Children receiving repeat DGA were significantly less likely to have pre-operative radiographs taken than those in the single DGA group. Operative radiographs were low in both groups. This indicates that the majority of children who received repeat DGA did not have any form of radiographic assessment throughout their treatment. Every effort should be made to complete a radiographic assessment, either pre-operatively or operatively, for each patient as correct identification of caries is significantly higher with the use of intra-oral radiographs.

Children who received more oral hygiene instruction (OHI) were more likely to receive repeat DGA. This is unusual, as one might assume those who receive more OHI are less likely to develop caries and require further DGAs. However, uptake and implementation of oral hygiene is debateable, and many parents find this an ongoing challenge.

The majority of repeat DGA patients were treated by a specialist or consultant at their DGA1. This is to be expected, as those with more complex treatments plans and complex medical histories are more likely to be treated by qualified paediatric dentists.

Children who received repeat DGA were more likely to receive restorations, and less likely to receive extractions at DGA1, compared to the single DGA group. This highlights a trend towards ‘saving’ teeth rather than extracting them in younger children and those who are medically compromised. Patients who received a repeat DGA were also more likely to be followed-up within the service providing the DGA, than those who received a single DGA.

The results of this study therefore suggest that the risk of repeat DGA increases as the age of a child at DGA1 decreases. It also suggests that a neurological disability, lack of pre-operative and/or operative radiographs and fewer extractions at DGA significantly increase the likelihood of repeat DGA in childhood.

4 Summary, Future Research and Conclusions.

4.1 Summary

This study has reported on the prevalence and characteristics of children receiving repeat DGA at two levels – the first examined overall repeat DGA prevalence and characteristics based on total number of repeat DGAs received, and the second examined repeat DGA prevalence and characteristics compared to control group of patients who received a single DGA.

The results challenge the current prevalence of repeat DGA across the UK, which varies widely depending on the study, and identify factors associated with significant increases in repeat DGA likelihood.

Future studies would benefit from a shorter time-period, in order to prevent the effects of outliers who received repeat DGAs years after DGA1. They would also benefit from additional information regarding the specific treatments per teeth, and success/failures at subsequent DGAs.

Furthermore, attendance at the follow-up appointment, and provision of long-term routine care within the SDS would have been advantageous to understand the long-term needs of patients compared to total number of DGAs received.

Nevertheless, the results firstly highlight differences amongst patients based on the total number of repeat DGAs they received. Existing literature is already available to highlight the increased needs of the repeat DGA population. However, no study has specifically identified patient characteristics based on total number of DGAs received. These findings add to the existing literature base, in that these patients have potentially modifiable risk factors that could help prevent multiple repeat DGAs.

Secondly, the results highlight significant differences in patients receiving a single DGA compared to those who received at two DGAs. The study compares differences in treatments provided at DGA1 episodes. Data collection was retrospective and for this analysis, this was an advantage. Treatment provided at DGA1 was not influenced by the operator as no patient had gone on to receive repeat DGAs at this point.

The results clearly highlight lack of radiographic assessment, at both the pre-operative and operative levels, as a risk factor for repeat DGAs, and increasing number of repeat DGAs. This is also true of age at DGA1, with younger patients significantly more likely to receive increasing number of repeat DGAs, and neurological disability. Finally, increased number of restorations provided at DGA1 was associated with increased risk of repeat DGAs.

4.2 Future Research

This is the only study to investigate in detail characteristics of patients based on the total number of DGAs received, and to compare repeat DGA patients to a control group. Further studies are required to verify the results.

The average prevalence of repeat DGA should be examined over a long period of time, with outliers accounted for and removed from the average. Treatment success at DGA and subsequent DGAs should also be examined long-term, such as the success of restorations or subsequent extractions and long-term complications (such as crowding or overeruption).

The uptake and implementation of oral hygiene advice by patients and parents/carers should be measured and recorded at specific intervals. This would help determine whether these interventions aid towards a reduced likelihood of repeat DGA. Behaviour

changes are challenging for parents and patients and are also very difficult to measure objectively.

In general terms, studies in repeat DGA have focused on patient characteristics and generalised treatment details. This study has found additional characteristics, such as provision of radiographs and number of extractions, can influence the number of repeat DGAs, and these should be carefully considered in future studies.

4.3 Conclusions

1. 6012 Dental General Anaesthetic (DGA) episodes were performed in North Yorkshire between January 2002 and May 2018
2. 275 DGA episodes were repeat DGAs
3. 1 patient received 5 DGAs, 6 patients received 4 DGAs, 20 patients received 3 DGAs and 248 patients received 2 DGAs
4. The overall prevalence of repeat DGA was 4.8%
5. The average time between DGA episodes was 3 years and 5 months
6. Age at DGA1 was inversely correlated with increasing number of DGAs
7. There was no difference in prevalence of repeat DGAs according to gender.
8. There was no difference in prevalence of repeat DGA and Index of Social Deprivation
9. Patients with a neurological comorbidity were 4 times more likely to receive repeat DGAs
10. There was no difference in prevalence of repeat DGA and social history concerns
11. Acute symptoms at DGA1 such as pain and swelling were high in all groups, and there was no significant difference associated with the number of repeat DGAs

12. The number of appointments a patient was not brough to was associated with a significant increase in number of repeat DGAs
13. Patients with a radiographic assessment were significantly more likely to receive a single DGA
14. Few repeat DGA patients received pre-operative or operative radiographs, and the lack of radiographs was significantly associated with number of repeat DGAs
15. Patients who received repeat DGAs were more likely to receive oral health advice
16. Differences in Operator Grade was found to be significant depending on number of repeat DGAs received
17. Patients who received fewer extractions at DGA1 were significantly more likely to receive repeat DGAs
18. Patients who received more restorations at DGA1 were significantly more likely to receive repeat DGAs
19. Follow-up of patients was significantly associated with increasing number of repeat DGAs

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Appendices

Appendix 1 Ethical Approval

NHS
Health Research Authority

London - West London & GTAC Research Ethics Committee
The Old Chapel
Royal Standard Place
Nottingham

29 January 2019

Mr Richard Balmer
Paediatric Dentistry Department
Leeds Dental Institute
Worsley Building, Clarendon Way
LS2 9LU

Dear Mr Balmer

Study title:	**Risk Factors for Children Receiving Repeat Dental General Anaesthesia**
REC reference:	**19/LO/0115**
Protocol number:	**NA**
IRAS project ID:	**258086**

Thank you for your letter of 28th January 2019, responding to the Proportionate Review Sub-Committee's request for changes to the documentation for the above study.

The revised documentation has been reviewed and approved by the sub-committee.

We plan to publish your research summary wording for the above study on the HRA website, together with your contact details. Publication will be no earlier than three months from the date of this favourable opinion letter. The expectation is that this information will be published for all studies that receive an ethical opinion but should you wish to provide a substitute contact point, wish to make a request to defer, or require further information, please contact please contact hra.studyregistration@nhs.net outlining the reasons for your request.

Under very limited circumstances (e.g. for student research which has received an unfavourable opinion), it may be possible to grant an exemption to the publication of the study.

Confirmation of ethical opinion

On behalf of the Committee, I am pleased to confirm a favourable ethical opinion for the above research on the basis described in the application form, protocol and supporting documentation as revised.

Conditions of the favourable opinion

The REC favourable opinion is subject to the following conditions being met prior to the start of the study.

Management permission must be obtained from each host organisation prior to the start of the study at the site concerned.

Management permission should be sought from all NHS organisations involved in the study in accordance with NHS research governance arrangements. Each NHS organisation must confirm through the signing of agreements and/or other documents that it has given permission for the research to proceed (except where explicitly specified otherwise).

Guidance on applying for HRA and HCRW Approval (England and Wales)/ NHS permission for research is available in the Integrated Research Application System, at www.hra.nhs.uk or at http://www.rdforum.nhs.uk.

Where a NHS organisation's role in the study is limited to identifying and referring potential participants to research sites ("participant identification centre"), guidance should be sought from the R&D office on the information it requires to give permission for this activity.

For non-NHS sites, site management permission should be obtained in accordance with the procedures of the relevant host organisation.

Sponsors are not required to notify the Committee of management permissions from host organisations.

Registration of Clinical Trials

All clinical trials (defined as the first four categories on the IRAS filter page) must be registered on a publicly accessible database. This should be before the first participant is recruited but no later than 6 weeks after recruitment of the first participant.

There is no requirement to separately notify the REC but you should do so at the earliest opportunity e.g. when submitting an amendment. We will audit the registration details as part of the annual progress reporting process.

To ensure transparency in research, we strongly recommend that all research is registered but for non-clinical trials this is not currently mandatory.

If a sponsor wishes to request a deferral for study registration within the required timeframe, they should contact hra.studyregistration@nhs.net. The expectation is that all clinical trials will be registered, however, in exceptional circumstances non registration may be permissible with prior agreement from the HRA. Guidance on where to register is provided on the HRA website.

It is the responsibility of the sponsor to ensure that all the conditions are complied with before the start of the study or its initiation at a particular site (as applicable).

Ethical review of research sites

The favourable opinion applies to all NHS sites taking part in the study, subject to management permission being obtained from the NHS/HSC R&D office prior to the start of the study (see "Conditions of the favourable opinion" above).

Approved documents

The documents reviewed and approved by the Committee are:

Document	*Version*	*Date*
Evidence of Sponsor insurance or indemnity (non NHS Sponsors only) [Indemnity]	1	11 December 2018
IRAS Application Form [IRAS_Form_17122018]		17 December 2018
Letter from sponsor [Confirmation of Sponsor Support]	1	11 December 2018
Other [Letter from Clinical Lead - proof that researchers are authorised to access dataset]	1	28 January 2019
Other [Response to questions asked by the sub-committee]	1	28 January 2019
Research protocol or project proposal [Research Protocol]	1	12 December 2018
Summary CV for Chief Investigator (CI) [Chief Investigator CV]	1	12 December 2018
Summary CV for student [Student CV]	1	12 December 2018
Summary CV for supervisor (student research) [Supervisor CV]	1	12 December 2018
Summary, synopsis or diagram (flowchart) of protocol in non technical language [Data collection sheet]	1	12 December 2018

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

After ethical review

Reporting requirements

The attached document "After ethical review – guidance for researchers" gives detailed guidance on reporting requirements for studies with a favourable opinion, including:

- Notifying substantial amendments
- Adding new sites and investigators
- Notification of serious breaches of the protocol
- Progress and safety reports
- Notifying the end of the study

The HRA website also provides guidance on these topics, which is updated in the light of changes in reporting requirements or procedures.

Feedback

You are invited to give your view of the service that you have received from the Research Ethics Service and the application procedure. If you wish to make your views known please use the feedback form available on the HRA website: http://www.hra.nhs.uk/about-the-hra/governance/quality-assurance

We are pleased to welcome researchers and R & D staff at our RES Committee members' training days – see details at http://www.hra.nhs.uk/hra-training/

19/LO/0115	**Please quote this number on all correspondence**

With the Committee's best wishes for the success of this project.

Yours sincerely

pp C Hallwell

Reverend Keith Lackenby

Chair

Email: NRESCommittee.London-WestLondon@nhs.net

Enclosures: *"After ethical review – guidance for researchers"*

Copy to: *Mr Richard Balmer*
James Hughes, Harrogate and District NHS Foundation Trust

Lead Nation HRA.Approval@nhs.net

Appendix 2 R&D Approval Harrogate and District Foundation Trust

Dear Lily

Full Study Title: **Risk Factors for Children Receiving Repeat Dental General Anaesthesia**
IRAS number: **258086**

REC Number: **19/LO/0115**

Please accept this email as confirmation that *Harrogate & District NHS Foundation Trust* has the Capacity and Capability to deliver the above study.

If you have any queries, please do not hesitate to contact me.

Best wishes

James

Dr James Hughes,
Research and Development Manager, Harrogate and District NHS Foundation Trust (HDFT)
Innovation Champion, HDFT – Medipex/York and Humber Academic Health Sciences Network (YHAHSN)

T: 01423 555697

Appendix 3 Data Collection Sheet

Information Collected	Notes
Date of Birth	Age at DGA

Gender	Male or Female
Postcode	Index of Multiple Deprivation Decile
Medical History	Neurological Deficit – Yes/No
Social History	Relevant Social Factor – Yes/No
Acute Symptoms	Pain, Swelling or Antibiotics – Yes/No
Attendance	Total Number of Appointments Booked Number of WNB (Was not bought) Appointments
Pre-operative Radiographs	Yes/No
Caries Prevention Advice	Yes/No
Treatment	Radiographs – Yes/No, Restorations/ Extractions
Operator Grade	Dental Core Trainee / Dental Officer / Paediatric Dentistry Registrar / Specialist in Paediatric Dentistry / Consultant in Paediatric Dentistry
Follow-up In SDS	Yes or No

Appendix 4 List of Acute Symptoms Reported in Single and Repeat DGA Patients

Acute Symptoms

Pain
Swelling
Antibiotic Prescription

Appendix 5 List of Neurological Disabilities reported in DGA Patients Medical History Records

Neurological Disability	Noonan Syndrome

Attention Deficit Hyperactivity Disorder	Angleman Syndrome
Autism Spectrum Disorder	Joubert's Syndrome
Down's Syndrome	Chromosome deletion
Cri du Chat Syndrome	Learning difficulties
Cornelia de Lange	Developmental delay
Fragile X Syndrome	Cerebral palsy
Williams Syndrome	Special needs
Behavioural difficulties	Epilepsy with neurological component

Appendix 6 List of Social History Risk Factors in Single and Repeat DGA Groups

Social History Risk Factor

Social Worker Involved
Foster Care
Parental Responsibility with Person Other than Parent
Care Order
Looked After Child
Residence Order
Lives with Person Other than Parent