Neighbourhood incidence rate of paediatric dental extractions under general anaesthetic in South West England

P. J. Lucas,*[1] D. Patsios,[2] K. Walls,[3] P. Neville,[4] P. Harwood,[5] J. G. Williams[6] and J. Sandy[7]

In brief

Demonstrates a one-year incidence rate for dental general anaesthetic of 7/1,000 among children in three local authorities in England. The highest prevalence was among 5–9-year-olds (12/1,000 children).

Suggests that rates of DGA were around three times higher in the most deprived than in the least deprived neighbourhoods, but the problem was widely dispersed with children admitted from 104/106 neighbourhoods.

Shows that reported rates of preventive actions by NHS dental professionals (applications of fluoride varnish and fissure sealant), were low for all ages and groups of children.

Introduction Extraction of decayed teeth is the most common reason for UK children aged 5-9 years to receive a general anaesthetic. Inequalities in oral health are well recognised, but is under-explored in dental general anaesthesia (DGA). **Methods** Secondary analysis of routinely collected data from three local authorities in South West England was used to assess: 1) dental activities recorded for children <18 years attending NHS general dental practitioners (GDP); 2) the incidence rate of DGA and disease severity among <16-year-olds; and 3) individual and neighbourhood factors associated with higher rates of child DGA, and greater severity of disease. **Results** Among 208,533 GDP appointments, rates of preventive action were low where 1/7 included fluoride varnish but 1/5 included permanent fillings. The incidence rate of DGA was 6.6 admissions for every 1,000 children, rising to 12.4/1,000 among 5–9-year-olds. A total of 86 (7.6%) children had previously received a DGA at the same hospital. Area deprivation was strongly associated with higher rates of DGA, but rates of DGA remained high in less deprived areas. No associations were observed between number of teeth removed and socio-economic status. **Conclusion** Too many children are receiving DGA, and too few preventive actions are recorded by GDPs. Area-based inequalities in DGA were apparent, but wealthy areas also experienced substantial childhood dental decay.

Introduction

Extraction of decayed teeth is the most common reason for UK children aged 5–9 years to receive a general anaesthetic.[1] Over the last ten years these admissions have increased every year;[2] in 2014–2015 over 46,000 under 16s were admitted for dental general anaesthetic (DGA).[3] The burden of pain and disruption for children is large.[4] The cost to the NHS is likely >£55 million (£1,179/procedure).[5] These figures are conservative estimates, given problems of inconsistent and under-reporting of DGA in both hospital episode statistics (HES) and surveys to date.[6,7] This problem is not restricted to the United Kingdom.[8–11]

[1]Reader in Child Health Research, [2]Senior Research Fellow School for Policy Studies, University of Bristol, 8 Priory Rd, Bristol, BS8 1TZ; [3]Senior Dental Officer, Primary Care Dental Service, University Hospitals Bristol NHS Foundation Trust, [4]Lecturer in Social Sciences, Bristol Dental Hospital, Lower Maudlin Street, Bristol, BS1 2LY; [5]Consultant in Dental Public Health, South West Centre, Public Heath England, 2 Rivergate, Bristol, BS1 6EW; [6]Consultant in Public Health, Bristol City Council, Public Health Team, City Hall, College Green, Bristol, BS1 5TR; [7]Dean of Faculty of Health Sciences, Senate House, Tyndall Avenue, Bristol, BS8 1TH
*Correspondence to: Patricia Lucas
Email: Patricia.Lucas@bristol.ac.uk

Refereed Paper. Accepted 3 October 2017
DOI: 10.1038/sj.bdj.2018.77

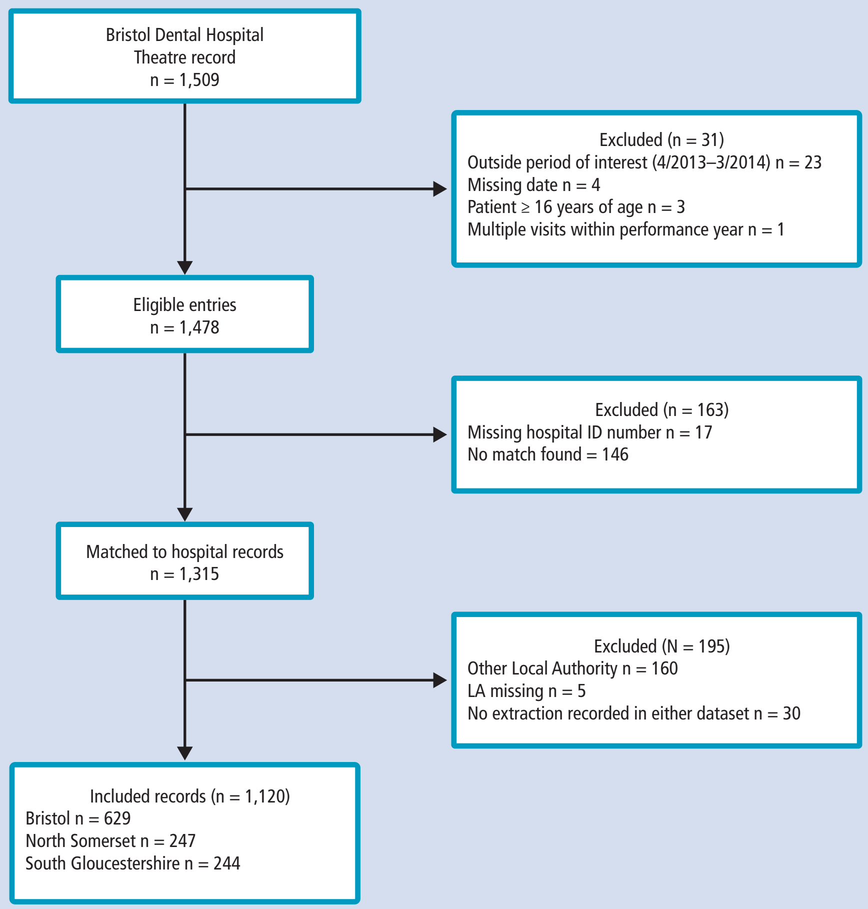
Dental caries is largely preventable, and admissions could be reduced by prevention and early treatment. Sugar reduction, good oral hygiene, tooth brushing, and fluoride use reduce caries risk.[12] The application of fluoride varnish and resin fissure sealant are key preventive actions.[13] Current evidence suggests financial and organisational barriers discourage a preventative approach to oral health management by dentists.[14,15]

Oral health is recognised as a key health inequality[16,17] particularly in childhood.[1] Disadvantaged groups and individuals have worse oral health and less access to dental care.[18–21] Those from more deprived groups experience both more decay,[22] and more untreated decay.[23] Despite free dental treatment for children in the UK, those from most deprived backgrounds visit the dentist less often and have higher rates of decay.[24]

Evidence regarding inequalities in tooth extractions under DGA is limited. The number of UK admissions is reported in HES,[2] but these aggregate data offer limited opportunities for analysis by child characteristics or severity of decay. A recent study used community dental clinic data instead, and found rates of DGA were 2.5–5 times higher in the most deprived neighbourhoods compared to the least deprived neighbourhoods in Southampton, UK.[25] Surveys of providers and attendees have established groups at higher risks of DGA, including those from more disadvantaged areas.[27,28] Analyses of hospital records suggest children who are younger, have behavioural challenges or more severe disease

Official journal of the British Dental Association.

Fig. 1 Flowchart of record inclusion, Bristol Dental Hospital Records



are more likely to receive a DGA.[26,27,29–31] In Western Australia, linked birth and hospital records have been used to show risks for DGA before the age of two years are higher among boys, indigenous children, those with intellectual disability, birth defects, and in areas without water fluoridation.[32]

To our knowledge, no studies have used hospital records to estimate rates of DGA in the population alongside estimates of disease severity, nor to examine area-based inequalities. Moreover, none have included area-based records of dental activity to examine possible associations between dental care activity and local rates of DGA. This paper aims to address these gaps by asking:

1. What is the uptake and pattern of NHS dental activity for children in three local authorities in England?
2. What is the burden of disease (incidence rate of DGAs and disease severity) for under-16s in the same area?
3. Which individual or neighbourhood factors are associated with higher rates of DGA, and greater numbers of teeth removed?

Materials and methods

Three neighbouring local authorities in South West England with a combined child population >200,000 were included in this study. None of these areas receive fluoridated water.[33] were included in this study. All routine referrals for DGA (ie, excluding children with complex medical needs and emergency procedures) from these local authorities are served by a single dental hospital.

We used two sets of routinely collected health data: National Health Service Business Service Authority (NHSBSA) and Bristol Dental Hospital (BDH) theatre records. NHSBSA data included a <18 population estimate. In addition we used Office of National Statistics estimates of <16 population per ward (2013 mid-year) for the population relevant to BDH records.[34] Neighbourhood deprivation was estimated using the 2015 Index of Multiple Deprivation (IMD), averages for electoral wards as a continuous variable and as national quintiles.[35,36]

Data analyses were conducted using IBM SPSS Statistics v23 and Microsoft Excel 2013 for calculation of derived NHSBSA variables. All tests and P values were two-tailed. Choropleth maps were prepared using ggplot2 and ggmap in R-project.[37]

Reported dental activities: data set, preparation and statistical analysis

NHSBSA provided reported GDP NHS treatments in the year to March 2014. These data are recorded by the GDP at the close of each course of treatment (CoT). A single CoT may involve several visits (for example, examination plus treatment appointments). A patient may have more than 1 CoT per year if they visit a dentist more than once. NHSBSA had been previously cleaned and prepared for us by information analysts within the NHS, and were reported to us both by CoT and by unique patient numbers for all under 18s.

Data from NHSBSA was provided as anonymised, aggregated data sets, summarising activities by neighbourhood (electoral ward), patient characteristics and CoT for all <18-year-olds in the area. We estimated population treatment rates (number of unique patients receiving a treatment/100 <18s in area), treatment rate per 100 CoT (number of CoT including treatment/100 CoTs), and variation in CoT by patient characteristics (age, gender, ethnicity and home IMD).

Extractions under DGA: data set, preparation and statistical analysis

Bristol Dental Hospital (BDH) theatre records provided a patient level database for all children (aged <16 years, N = 1,509) receiving a DGA in the year to March 2014 matched to their hospital records.

Theatre records were accessed including the recording date of procedure, gender, trust number (a unique anonymous ID number), age in completed years, the number of teeth removed, and which teeth removed (total number of teeth removed was calculated where this was missing – where the total number of teeth removed was recorded as zero, these records were retained). Records were checked for eligibility and completeness and 31 ineligible or incomplete cases were excluded (Fig. 1). We supplied the BDH data intelligence team with 1,461 unique ID numbers, from which an anonymised data set comprising date of procedure, teeth extracted, calculated age at procedure date, home electoral ward, treatment details, and any admissions within the previous five years was retrieved. A total of 146 cases could not be matched to their BDH records. Data were

Table 1 Reported NHS dental activities by local authority reported, performance year 2013-14

Local authority name	Pop 0-18*	No. of unique patients**	Unique patient/100 <18s	CoT/unique patient	% of Unique Patients with >1			
					Fluoride varnish	Fissure sealants	Permanent fillings	Extractions
City of Bristol	96,201	54,393	56.5	1.6	23.1	2.1	28.4	7
North Somerset	44,694	30,575	68.4	1.7	13.1	1.9	25.5	5.5
South Gloucestershire	60,457	41,090	68	1.7	12.9	1.3	24.8	5.6
Total	**201,351**	**126,058**	**62.6**	**1.7**	**17.3**	**1.8**	**26.5**	**6.2**

*2013 Mid-year estimates
**Since patient attendance is the reporting category, patients can be counted more than once if they attend within a year and/or in different commissioning areas, and total patient counts can include amended, withdrawn and deleted records. The count of unique patient identifiers is therefore the best estimate of the number of unique patients attending.

checked for consistency and completeness. Date of birth data was complete, recorded home post code was missing or false for five cases and gender was discrepant in one case (treated as missing). Hospital treatment codes were used to check that these also showed dental extractions had taken place – theatre book records were assumed to be more accurate in this case – and a total of 30 records were excluded where neither dataset recorded an extraction (Fig. 1).

Patients from outside the three local authorities (Bristol, South Gloucestershire and North Somerset) which provided routine referrals, and those whose home local authority was missing were excluded before analysis (Fig. 1). We report here the local authority and ward level incidence rate of DGA; that is the number of <16-year-olds admitted to BDH for extractions under DGA per 1,000 population. These data were used to produce choropleth maps.

Ward level variation in DGA: data set, preparation and statistical analysis

We created a ward level data set from the NHSBSA data and ward counts of BDH cases.

Rate of DGA was analysed at neighbourhood (ward) level; the number of DGA cases originating in each ward was calculated and these totals, along with population estimates, were matched to the NHSBSA ward-level data set. We report the one-year incidence rate for DGA (the number of new DGA treatment cases as a proportion of average population during the period), acknowledging we do not have data on true disease incidence or prevalence during this period.

Pearson's correlation coefficients were used to assess associations between neighbourhood characteristics and ward-level incidence rate of DGA. Only those variables significantly correlated ($P < 0.05$) with the dependent variables were used in a multivariable analysis. We undertook stepwise multiple regression adjusted for ward-level child population (model 1), child population and area deprivation (IMD) (model 2), child population, area deprivation and rates of treated decay (extractions and fillings per CoT), and child population, area deprivation, rates of treated decay and rates of preventive action (use of fluoride varnish, fissure sealant, and NHS treatment) (model 4) to ascertain the independent contribution of variables to the outcome. This enables us to comment on the extent to which the additional variables in each model improve our explanation of the data.

The number of teeth removed per child (a marker of disease severity) was analysed at an individual level as a continuous variable using ANOVA, and as a binary variable (<5 teeth removed, ≥5 teeth removed) in a binary logistic regression.

Table 2 Treatment activities in one year period by child characteristic (not accounting for multiple treatments per patient)

	Total CoTs	Treatment rate per 100 course of treatment (CoT)			
		Fluoride varnish	Fissure sealants	Permanent fillings	Extractions
0 to4	36,220	8.6	0	5.2	0.2
5 to 9	73,154	14.9	1.6	22.5	6.7
10 to 15	29,399	6.1	0.7	25.6	2.6
16-18	69,760	19	1.5	24.3	3.8
Female	104,161	13.8	1.2	20.2	4.2
Male	104,372	14.1	1.1	20.9	3.9
BME	7,417	18.6	3	26.7	6.6
White	113,083	15.9	1	21.6	4.2
Other, unspecified or declined	88,033	11	1.1	18.7	3.6
IMD 2015 National quintile* lowest 1	50,341	20.8	2	25.2	5.3
2	43,910	18.8	1.2	21.9	4
3	16,503	13.3	0.9	21.4	3.8
4	48,135	8.2	0.7	18.2	3.4
Highest 5	49,644	8.4	0.7	16.6	3.4
Total*	**208,533**	**13.9**	**1.2**	**20.6**	**4**

*Adjusted IMD 2015 scores. Source of IMD figures: English indices of deprivation 2015, DCLG website, https://www.gov.uk/government/statistics/english-indices-of-deprivation-2015

Patient involvement

This project was conducted as part of a Health Integration Team involving practitioners, local policy makers, third-sector providers, researchers and parents (www.bonee.org). Stakeholders were involved at every stage of the research, including planning, design and interpretation. Findings were disseminated to parents via BDH and local children's centres.

Official journal of the British Dental Association.

Fig. 2 Ward level rates of DGA (number of admissions/1,000 child population)

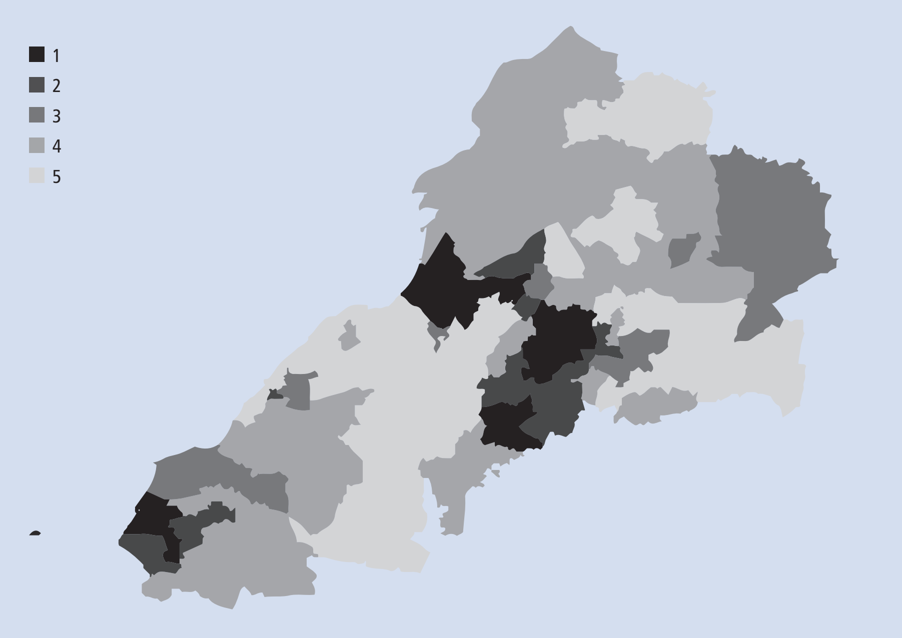
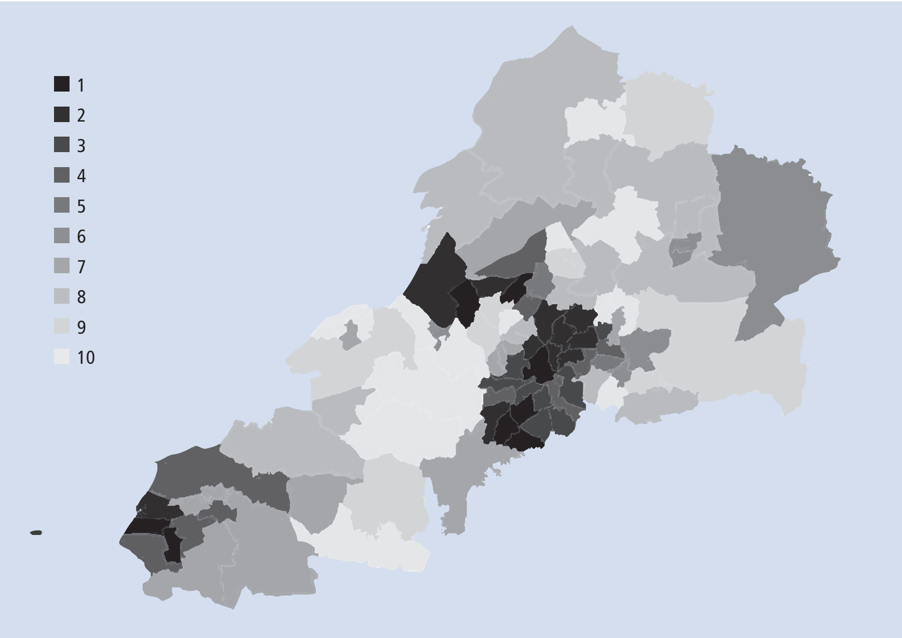


Fig. 3 Ward level national IMD decile (2015)



Ethics

The project was approved by the University of Bristol School for Policy Studies Research Ethics Committee. NHS permission for research was granted for us to access anonymous datasets from research and innovation at the University Hospitals Bristol NHS Foundation Trust (CH/2014/4,756) and the CaldEcott Guardian. The researchers did not have access to patient identifiable data.

Results

Reported dental activities

NHS dental activities were reported for 126,058 unique patients, representing 63 attendees per 100 <18 years in the population (Table 1). Among those who attend, mean attendance was 1.7 CoT in the year, and 17.3% received at least one application of fluoride varnish, 1.8% fissure sealant, 26.5% permanent fillings and 6.2% (or 7,789 children) extractions in the dentists' chair.

Dental activity per CoT in a one-year period by age group, gender, ethnicity and home IMD, are presented in Table 2. Children aged 3–18 years should be seen by a dentist and have fluoride varnish applied twice a year, those at higher risk of dental decay should be seen more frequently and have fissure sealants applied.[13] Thus, we expect fluoride varnish a minimum of once per child. Fissure sealants should be used most commonly in the 5–9 age group. While 22.5% of CoTs among 5–9-year-olds include at least one permanent filling and 6.7% an extraction (most likely for caries in this age group), only 14.9% and 1.6% of CoTs include fluoride varnish and fissures sealant, respectively. Rates of permanent filling (25.2%), extraction (5.3%), fluoride varnish (20.8%) and fissure sealant (2.0%) per CoT were highest in the most deprived neighbourhoods. Rates of

Table 3 Characteristics of children presenting for dental extraction under general anaesthetic

	Total number	/1,000 <16 population*	/1,000 5-9-year -olds*	Female (N, %)***	Child age median (IQR)	BME (n, %)	Ethnicity missing/ not stated	Total teeth removed (average per child)	Number of teeth removed per child (median, IQR)**
Bristol	629	7.7	14.7	303 (48.2%)	6 (5-9)	154 (24.5%)	41 (6.5%)	3248 (5.2)	5 (3-8)
North Somerset	247	6.7	12.9	131 (53.0%)	7 (5-9)	12 (4.9%)	20 (8.1%)	1278 (5.2)	4 (2-8)
South Gloucestershire	244	4.9	83	109 (44.7%)	7 (5-10)	16 (6.6%)	26 (10.7%)	1185 (5)	4 (3-7)
Total	**1120**	**6.6**	**12.4**	**543 (48.5%)**	**7 (5-9)**	**182 (16.3%)**	**87 (7.8%)**	**5711 (5.2)**	**4 (2-8)**

*Mid 2013 Ward Estimates. **Data missing for 21 cases. ***Data missing for 1 case.

Official journal of the British Dental Association.

both treatment and preventive actions were higher in Black and Minority Ethnic (BME) than in non-BME patients, but ethnicity was unrecorded for a large number of patients so these data are not reliable.

Extractions under DGA

Records of 1,509 procedures undertaken in the BDH general anaesthetic theatre were provided, with a total of 5,707 teeth removed.

Following matching and exclusions we include 1,120 recorded DGA in the year to March 2014 (Fig. 1). Most were young (median age 7 years) and most had >four teeth removed (Table 3). Of the 1,120 children receiving a DGA, 470 (42.0%) came from the most deprived neighbourhoods (IMD quintile 1), compared to 137 (12.2%) from the least deprived (IMD quintile 5).

The one-year incidence rate of extractions under general anaesthetic was 6.6 for every 1,000 under 16 in the population, rising to 7.7 in the City of Bristol, and 12.4/1,000 among 5–9-year-olds (Table 3). Both the number (N = 629) and rate of DGA admission was highest in the City of Bristol, and the highest incidence rate was among 5–9 years old from Bristol (14.7/1,000 population).

Eighty-six (7.6%) of the children receiving a DGA in this year (for whom we could match records) had previously been admitted for this treatment. Seventy-seven children had received two DGAs, and nine children had received three or four. Among those repeat attenders, median age at first attendance was five years.

Ward level variation in rates of DGA

We compared the incidence rate of DGA between 106 electoral wards. Rates of DGA varied between zero and 20.9 per 1,000 child population (Fig. 2). Figure 3 shows IMD 2015 national decile for the same electoral wards, and Figure 4 the distribution of incidence rate by ward IMD decile where 1 is the most deprived. Incidence rate of DGA was highest in the most deprived wards and lowest in the least deprived wards, with 40% of attendances originating from wards in the lowest national quintile for IMD, but considerable variation between similar wards was observed.

Neighbourhood deprivation correlated significantly with all measures of dental service provision tested (Table 4). More deprived areas and those with higher rates of all dental activities including treatment for decay and preventive actions had higher rates of DGA.

Fig. 4 Ward level IMD decile (2015) and proportion of the child population experiencing DGA (mean and 95% confidence intervals)

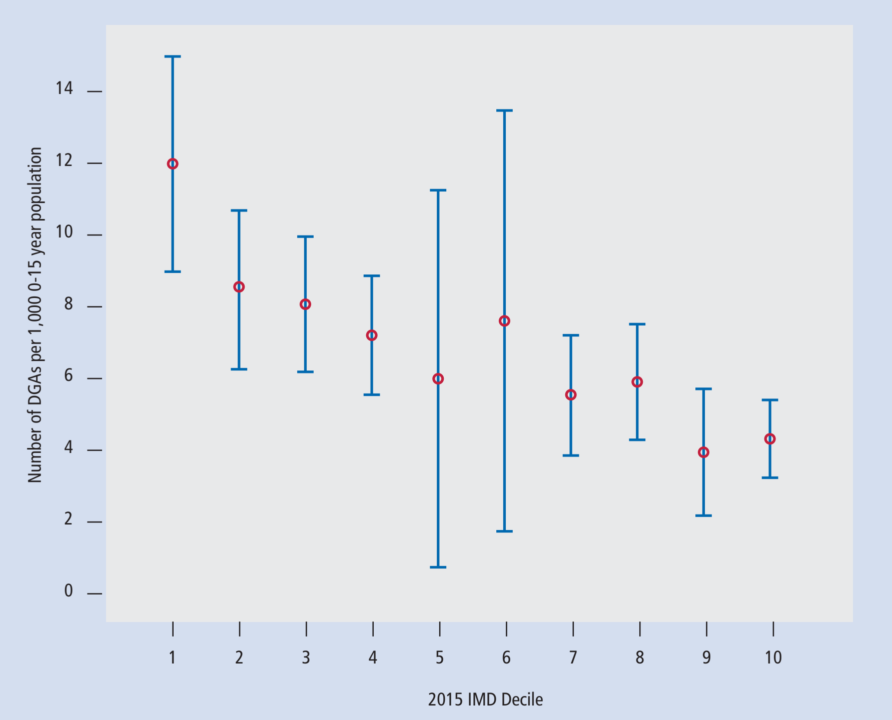


Table 4 Ward level variation in DGA incidence rate, NHS treatment uptake, and NHS treatments provided (N = 106 wards)

Variable	Mean (std deviation)	Pearsons R[†]	Model summary		95% confidence intervals for Beta
Total number of children's DGA	10.6 (9.8)				
Total 0–15 population	1508.4 (831.7)	0.78**	1[††]	R2 = 0.60 SE = 6.21	0.00; 0.01**
Average IMD 2015 score	16.3 (11.7)	0.57**	2[††]	R2 = 0.77 SE = 4.73	0.22; 0.50**
Extractions rate per CoT	3.8 (1.0)	0.33**	3[††]	R2 = 0.77	-1.36; 1.01
Permanent fillings rate per CoT	20.0 (4.1)	0.49**		SE 4.77	-0.60; 0.03
Fluoride varnish vate per CoT	12.4 (7.4)	0.63**	4[††]	R2 = 0.82	0.30; 0.62**
Fissure sealants rate per CoT	1.0 (0.9)	0.35**		SE 4.18	-1.08; 1.32
Number of children receiving NHS treatment per 1,000 child population	794.8 (691.1)	0.37**			-0.03; 0.001

**P <0.001 (2-tailed). [†]Univariate correlation with number of children admitted. [††]Model 1 adjusted for ward level child population, Model 2 child population and area deprivation (IMD), Model 3 child population, area deprivation and rates of treated decay (Extractions and fillings per CoT), and model 4 child population, area deprivation, rates of treated decay and rates of preventive action (use of fluoride varnish, fissure sealant, and NHS treatment)

Multiple linear regressions (Table 4) suggest that after adjusting for child population size, area deprivation and rates of preventive actions (specifically application of fluoride varnish) are associated with significantly higher rates of DGA (Table 4, Model 4, R2 = 0.8 SE 4.2). For every 1% increase in fluoride varnish application we see an increase in the incidence rate of 0.3–0.6 child DGAs per 1,000 children, and similarly for a one unit increase in IMD, an additional 0.3–0.5 children per 1,000 receiving DGA in a one year period. In contrast, including rates of treated decay (extractions and fillings) did not improve the model. When we include all our predictor variables, 82% of the variance in ward level incidence rate is explained.

Inequalities in disease severity were examined by analysing the number of extractions per patient (Table 5). Children aged 5–9 years had the largest average number of teeth removed per child (mean of 5.6 teeth, SD = 3.2) and those aged 10–15 years the smallest (mean of 3.7, SD = 3.3). We found no associations with any measure of area deprivation or service quality and the number of decayed teeth removed. The risk of having extensive decay (defined as five or more teeth removed) was significantly associated with child age only, where those in the age group 10–15 years were 70% less likely to have had five or more teeth extracted than the <4 reference group. The analysis of number of teeth removed per child as a continuous variable showed the same pattern of results.

Table 5 Average number of teeth removedper patient by patient characteristics (N = 1,099 children)

		Mean (SD)
Local authorities	Bristol	5.3 (3.26)
	North Somerset	5.2 (3.55)
	South Gloucestershire	5.1 (3.15)
Age group	0-4	5.5 (3.87)
	5-9	5.6 (3.19)
	10-15	3.7 (3.76)
Gender	Female	5.2 (3.24)
	Male	5.2 (3.26)
	Unmatched - missing	5.4 (3.83)
Ethnic group	White	5.2 (3.32)
	Black/minority ethnic	5.4 (3.31)
	Missing/not stated	4.6 (3.01)
Ward IMD 2015 national quintile	Lowest 1	5.5 (3.39)
	2	5.4 (3.32)
	3	5.1 (3.31)
	4	4.9 (3.16)
	Highest 5	4.3 (2.92)
All sample		**5.2 (3.36)**

Discussion

Summary of findings

We estimate that 40% of the child population did not visit a dentist in a one year period. Evidence suggests that preventive actions are underused by GDP in this region, with only 1/7 CoTs including fluoride varnish and 1/83 fissure sealant.

Around seven in every 1,000 <16-year-olds per year were admitted for DGA, of whom one in 13 were repeat admissions. Incidence rates were highest among 5–9-year-olds, in the most deprived neighbourhoods, and in areas with higher rates of fluoride varnish use. It is not possible to disentangle the causality and confounding in these observed relationships.

Most children had >4 teeth removed. Younger children had, on average, more teeth removed than older children. Number of teeth removed did not vary by gender, ethnicity or neighbourhood deprivation.

Results in context

Our data broadly agrees with previous studies reporting that 32.5% of children do not attend dental services,[39] and that 8% of 3-year-olds and 25% of 5-year-olds have experienced dental decay in at least one tooth.[40,41] Shaban *et al.* used the 2003 dental health survey data to comment on inequalities in dental provision.[24] Unlike us, they found higher rates of fissure sealant in less deprived groups (considering mothers education, family social class, and area deprivation). Their data is drawn from a smaller sample but is a more accurate estimate of total treatment incidence as it includes non-NHS treatment and treatment ever applied (while we only comment on application within the year by NHS provider) so is probably a more accurate estimate of total treatment incidence.[24] Their data do not allow them to compare rates by child age.

HES data over the period 1997–2006 show around 30% of children admitted for DGA were from areas of high deprivation.[2] In our sample, a larger proportion (40%) came from areas of high deprivation. This difference may simply reflect the different population samples; due to its geographic reach, Bristol Dental Hospital over-samples urban populations with higher rates of deprivation. We also report slightly different cases, we excluded children with complex healthcare needs who commonly receive DGA for reasons other than decay severity.[42,43] Finally, our study reports cases seven years later than the previous publication, and it is possible that nationally observed reductions in rates of dental decay at age 5[41] have masked widening of inequalities if improvements have been concentrated in the most advantaged groups.

The young age of those receiving DGA in our sample confirms the young age at which caries is identified[40,41] and dentists' preference for DGA for those they judge less likely to tolerate procedures under local anaesthetic including for the very young.[44]

We confirm the relationship observed by others between neighbourhood deprivation and rates of poor dental health in childhood.[41] In particular, South Gloucestershire (the local authority with least deprivation in our sample) experienced low DGA rates echoing low rates of decay in national surveys.[41]

The observed association between higher rates of fluoride varnish use and DGA

Official journal of the British Dental Association.

appears to contradict evidence of its role in reducing decay.[45] In our population level study this probably reflects greater fluoride use in areas with higher rates of decay, and does not suggest fluoride use is ineffective. However, even assuming underreporting by GDPs, local rates of fluoride varnish application for young children are probably not sufficient to prevent the early decay most likely to result in DGA.

Given changes in practice, increasing rates of DGAs may not imply increasing disease rates.[6] However, the high use of both DGA and permanent fillings among children studied here do represent large numbers of diseased teeth and the high burden of preventable disease in this population.

In studies of otherwise healthy children, prior DGA admissions are reported for 7.4% of children in a Leeds teaching hospital,[46] and 5.6% of children using HES data.[2] We report a rate similar to that found in the teaching hospital here, confirming the use of hospital records as a more accurate (and higher) record of repeat admissions and supporting the generalisability of the findings in Leeds and Bristol.

Strengths and limitations

The study strength lies in the accurate recording of attendance for DGA across one region, and in our ability to link individual records and area-based data. This allowed examination of area incidence rate and relationships to neighbourhood deprivation and dental activities. We were also able to comment on the number of teeth removed per child, which is rarely reported. This identifies the number of diseased teeth, but clinical and social features aside from severity of decay will determine whether teeth are removed or restored.

It is likely that our data still underreports DGAs. Children admitted for emergency surgery for acute dental pain, and the 11% of dental theatre records unmatched to hospital records are missing from the analysis. However, we believe these would account for a relatively modest number of missing records and have little effect on incidence rates.

Preventive actions by GDPs may also be underreported. GDPs may not accurately record all dental activities, particularly since fluoride varnish and fissure sealant do not generate additional payments.[37] The study only reports activity within the NHS, so any private treatments received by children are not reported. Taken together these may substantially underreport GDP preventive activities, particularly in wealthier areas where more children will attend private practices.

In this observational study we are not able to attribute causality to the observed associations. Although we can comment on patterns of disease by neighbourhood, we cannot say with confidence what causes these differences. We also cannot comment on why these children received a DGA, so cannot differentiate whether this was due to young age, extent of decay, or dental anxiety.

Implications for policy, practice and future research

Our data show that the significant inequalities observed in child oral health are repeated in decay requiring extraction of teeth, although all neighbourhoods experienced DGA. These admissions are preventable, and follow disease established before the age of five years. The message for clinicians and policymakers is clear: prevention of severe dental caries should be a priority for child health in all areas. Children with dental pain present in dentists, community, primary and emergency health services and all could usefully play a role in follow up and prevention.[47] Greater knowledge of oral health is needed among the entire child workforce.[48]

Despite Public Health England recommendations, the vast majority of NHS dental appointments for children did not include the preventive application of fluoride varnish. Few areas of England provide fluoridated water[33] despite its known benefits for reduction of caries and tooth extractions[33,45,49] so this underuse of fluoride varnish is important. Use of fissure sealant was vanishingly rare (1.6%). Moving dental healthcare to a more preventive model is a significant national challenge.[50–54] Policy makers must attend to the incentives (and disincentives) for preventive action, but individual clinicians can and should improve their practice. The UK Children's Oral Health Improvement plan and the increased role of local authorities in oral health promotion are positive moves, but research to support changes in professional practice is required.[47,55]

Research into avoiding readmissions for DGA is urgently needed. Fewer than half of those performing DGA have appropriate arrangements for ongoing preventive care.[6] Studies have explored parents information needs post DGA,[56] and there is a growing body of research into changing parental oral healthcare.[57–59] But current clinical guidelines only cover post-surgery care, and make no mention of the need for post-surgery consultation with a general dental practitioner or other health professional.[60]

Conclusions

Too many children are receiving DGA in the area surveyed, and too few children receive preventive treatments from GDPs. Area-based inequalities in DGA incidence were apparent, but wealthy areas also experience significant disease burden. A preventive approach to oral health is needed, employing the full range of preventive options available including using dietary and fluoride interventions by GDPs and supported by all healthcare professionals to reduce dental decay levels and DGAs in children.

Acknowledgements
The study was funded by a grant from the Elizabeth Blackwell Institute for Health Research, University of Bristol, and the Wellcome Trust Institutional Strategic Support Fund. (Grant code 097,822/Z/11/ZR) and by Bristol Health Partners' support to the BoNEE HIT (Bristol Network for Equality in Early Years Health and Wellbeing, Health Integration Team). Dr Lucas' time was further supported by the University of Bristol School of Oral and Dental Science. We would like to thank members of the BoNEE team who contributed to the planning and analysis of this study. Our thanks to Sarah Bain for assistance accessing the theatre records, Kwok Lee and Linda Wadey for data matching with University Hospital Bristol records, and Rob Wise for preparing NHSBSA data sets. We would also like to thank Hannah Lepper for preparation of the choropleth maps.

As the study used routinely collected data for audit and service improvement, formal scrutiny by an NHS research ethics committee was not required. The study was reviewed by the University of Bristol School for Policy Studies Ethics Committee, and granted approval on 13 January 2015. In addition, we were granted NHS permission (CH/2014/4,756, 3/12/2014) and permission from the Caldicott Guardian for access to fully anonymised University Hospital records (granted 15/12/2014). Anonymity of patient data was protected by the UHBristol information analyst, who extracted the required data and provided it to the research team with all identifiers removed (date of birth and home postcode) and patient unique, non-identifiable identification numbers inserted. NHS BSA data was supplied by information analysts in NHS England, and the research team was provided with aggregated data to protect anonymity.

Details of contributions
PJL, KW, JS, JW and PH conceived of the study. PJL, KW & JS secured funding. PJL, DP, KW and PH designed the study, with contributions from all authors. DP collected the data with assistance from KW and prepared the database. PJL and DP conducted the analyses. All authors had access to all of the data, including statistical reports and tables and can take responsibility for the integrity of the data and the accuracy of the data analysis. PJL drafted the manuscript, all authors reviewed and contributed to the final version.

Patricia J Lucas is the guarantor for the study and affirms that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

Data sharing: ward level data and SPSS syntax are available from the corresponding author on request. Patient consent for data sharing was not obtained but the potential benefits of sharing these data outweigh the potential harms because data are fully anonymised and available at aggregate level only.
The reporting of this study conforms to the The REporting of studies Conducted using Observational Routinely-collected health Data (RECORD) Statement.

1. RCS. The state of children's oral health in England. London: The Faculty of Dental Surgery, Royal College of Surgeons, 2015.
2. Moles D R, Ashley P. Hospital admissions for dental care in children: England 1997–2006. *Br Dent J* 2009; **206:** E14.
3. HSCIC. Hospital Episode Statistics. Admitted Patient Care – England, 2014–2015. Leeds: Health and Social Care Information Centre, 2015.
4. Olley R C, Hosey M T, Renton T, Gallagher J. Why are children still having preventable extractions under general anaesthetic? A service evaluation of the views of parents of a high caries risk group of children. *Br Dent J* 2011; **210:** E13.
5. Curtis L, Burns A. Unit Costs of Health & Social Care 2015. 2015. Canterbury, Kent: Personal Social Services Research Unit, The University of Kent.
6. Robertson S, Ni Chaollai A, Dyer T A. What do we really know about UK paediatric dental general anaesthesia services? *Br Dent J* 2012; **212:** 165–167.
7. Ni Chaollai A, Robertson S, Dyer T A, Balmer R C, Fayle S A. An evaluation of paediatric dental general anaesthesia in Yorkshire and the Humber. *Br Dent J* 2010; **209:** E20.
8. Thomson W M. Public Health Aspects of Paediatric Dental Treatment under General Anaesthetic. *Dent J* 2016; **4:** 20.
9. Peerbhay F, Barrie R B. The burden of early childhood caries in the Western Cape Public Service in relation to dental general anaesthesia: implications for prevention. *SADJ* 2012; **67:** 14–16, 18–19.
10. US Department of Health and Human Services. Oral Health in America: A Report of the Surgeon General. Rockville, MD: US Department of Health and Human Services, National Institute of Dental and Craniofacial Research, National Institutes of Health, 2000.
11. Rowan-Legg A. Oral health care for children-a call for action. *Paediatr Child Health* 2013; **18:** 37–43.
12. Harris R, Nicoll A D, Adair P M, Pine C M. Risk factors for dental caries in young children: a systematic review of the literature. *Community Dent Health* 2004; **21:** 71–85.
13. Public Health England. Delivering Better Oral Health. Public Health England, 2014.
14. Williams D M, Sheiham A, Watt R G. Oral health professionals and social determinants. *Br Dent J* 2013; **214:** 427.
15. Dyer T A, Robinson P G. General health promotion in general dental practice-the involvement of the dental team Part 2: A qualitative and quantitative investigation of the views of practice principals in South Yorkshire. *Br Dent J* 2006; **201:** 45–51; discussion 31.
16. Watt R, Sheiham A. Inequalities in oral health: a review of the evidence and recommendations for action. *Br Dent J* 1999; **187:** 6–12.
17. Jain P, Shankar A, Ramaiah S. Dental caries and social deprivation. *Lancet* 2007; **369:** 639.
18. Shen J, Wildman J, Steele J. Measuring and decomposing oral health inequalities in an UK population. *Community Dent Oral Epidemiol* 2013; **41:** 481–489.
19. Wingfield T. Promoting dental health among high risk groups. *Br Med J* 2015; **350:** h2065.
20. Watt R, Sheiham A. Integrating the common risk factor approach into a social determinants framework. *Community Dent Oral Epidemiol* 2012; **40:** 289–296.
21. Watt R, Williams D M, Sheiham A. The role of the dental team in promoting health equity. *Br Dent J* 2014; **216:** 11–14.
22. Schwendicke F, Dorfer C E, Schlattmann P, Page L F, Thomson W M, Paris S. Socioeconomic inequality and caries: a systematic review and meta-analysis. *J Dent Res* 2015; **94:** 10–18.
23. Mejia G, Jamieson L M, Ha D, Spencer A J. Greater inequalities in dental treatment than in disease experience. *J Dent Res* 2014; **93:** 966–971.
24. Shaban R, Kassim S, Sabbah W. Socioeconomic inequality in the provision of specific preventive dental interventions among children in the UK: Children's Dental Health Survey 2003. *Br Dent J* 2017; **222:** 865–869.
25. Mortimore A, Wilkinson R, John J H. Exploring the potential value of using data on dental extractions under general anaesthesia (DGA) to monitor the impact of dental decay in children. *Br Dent J* 2017; **222:** 778–781.
26. Macpherson L M, Pine C M, Tochel C, Burnside G, Hosey M T, Adair P. Factors influencing referral of children for dental extractions under general and local anaesthesia. *Community Dent Health* 2005; **22:** 282–288.
27. Hosey M T, Bryce J, Harris P, McHugh S, Campbell C. The behaviour, social status and number of teeth extracted in children under general anaesthesia: a referral centre revisited. *Br Dent J* 2006; **200:** 331–334, discussion 27.
28. Cameron F L, Weaver L T, Wright C M, Welbury R R. Dietary and social characteristics of children with severe tooth decay. *Scot Med J* 2006; **51:** 26–29.
29. Albadri S S, Lee S, Lee G T, Llewelyn R, Blinkhorn A S, Mackie I C. The use of general anaesthesia for the extraction of children's teeth. Results from two UK dental hospitals. *Eur Arch Paediatr Dent* 2006; **7:** 110–115.
30. Holt R D, Rule D C, Davenport E S, Fung D E. The use of general anaesthesia for tooth extraction in children in London: a multi-centre study. *Br Dent J* 1992; **173:** 333–339.
31. Camilleri A, Roberts G, Ashley A, Scheer B. Analysis of paediatric dental care provided under general anaesthesia and levels of dental disease in two hospitals. *Br Dent J* 2004; **196:** 219–223.
32. Slack-Smith L, Colvin L, Leonard H, Kilpatrick N, Read A, Messer L B. Dental admissions in children under two years – a total-population investigation. *Child* 2012; **39:** 253–259.
33. PHE. Water fluoridation Health monitoring report for England 2014. London: Public Health England, 2014.
34. Office for National Statistics. Annual Small Area Population Estimates: Mid-2014 and Mid-2013. 2015. Available at https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/bulletins/annualsmallareapopulationestimates/previousReleases (accessed January 2018).
35. Department for Communities and Local Government. English indices of deprivation 2015. 2015. Available at https://www.gov.uk/government/statistics/english-indices-of-deprivation-2015 (accessed January 2018).
36. Hampshire county Council. 2015 IMD Deprivation Data: Index of MultipleDeprivation Ward Data 2015. Available at http://www3.hants.gov.uk/factsandfigures/figures-economics/deprivation_indices.htm (accessed January 2018).
37. R Core Team. The R project for statistical computing. Vienna, Austria: R Foundation for Statistical Computing; 2016. Available from: https://www.R-project.org/ (accessed January 2018).
38. Department of Health. Standard general dental services contract. London: Department of Health, 2006.
39. PHE. South West Oral Health Needs Assessment and Profiles: Profile of oral health in Bristol. Local Knowledge and Intelligence Service (South West), Public Health England, 2015–2024. 2015.
40. PHE. Dental public health epidemiology programme Oral health survey of three-year-old children 2013. A report on the prevalence and severity of dental decay. London: Public Health England, 2014.
41. PHE. National Dental Epidemiology Programme for England: oral health survey of five-year-old children 2015. A report on the prevalence and severity of dental decay. London: Public Health England, 2016.
42. Camilleri A, Roberts G, Ashley P, Scheer B. Analysis of paediatric dental care provided under general anaesthesia and levels of dental disease in two hospitals. *Br Dent J* 2004; **196:** 219–223.
43. Harrison M G, Roberts G J. Comprehensive dental treatment of healthy and chronically sick children under intubation general anaesthesia during a 5-year period. *Br Dent J* 1998; **184:** 503–506.
44. Tyrere G L. Referrals for dental general anaesthesia-how many really need GA? *Br Dent J* 1999; **187:** 440–443.
45. Marinho V C, Worthington H V, Walsh T, Clarkson J E. Fluoride varnishes for preventing dental caries in children and adolescents. *Cochrane Database Syst Rev* 2013; **7:** CD002279.
46. Tahmassebi J F, Achol L T, Fayle S A. Analysis of dental care of children receiving comprehensive care under general anaesthesia at a teaching hospital in England. *Eur Arch Paediatr Dent* 2014; **15:** 353–360.
47. NICE. Oral health: approaches for local authorities and their partners to improve the oral health of their communities. National Institute for Health and Care Excellence, 2014.
48. Bottenberg P, Van Melckebeke L, Louckx F, Vandenplas Y. Knowledge of Flemish paediatricians about children's oral health – results of a survey. *Acta Paediatr* 2008; **97:** 959–963.
49. Torgesen I. Water fluoridation almost halves hospital admissions for dental caries, report finds. *BMJ* 2014; **348:** g2394.
50. Garcia R I, Sohn W. The Paradigm Shift to Prevention and Its Relationship to Dental Education. *J Dent Educ* 2012; **76:** 36–45.
51. Brocklehurst P, Price J, Glenny A M *et al.* The effect of different methods of remuneration on the behaviour of primary care dentists. *Cochrane Database Syst Rev* 2013; **11:** CD009853.
52. Best H A, Eaton K A, Plasschaert A *et al.* Continuing professional development-global perspectives: synopsis of a workshop held during the International Association of Dental Research meeting in Gothenburg, Sweden, 2003. Part 2: regulatory and accreditation systems and evidence for improving the performance of the dental team. *Eur J Dent Educ* 2005; **9:** 66–72.
53. Firmstone V R, Elley K M, Skrybant M T, Fry-Smith A, Bayliss S, Torgerson C J. Systematic review of the effectiveness of continuing dental professional development on learning, behaviour, or patient outcomes. *J Dent Educ* 2013; **77:** 300–315.
54. NICE. Oral health promotion: general dental practice. Nice Guideline 30. National Institute of Health and Clinical Excellence, 2015.
55. PHE. Children's Oral Health Improvement Programme Board Action Plan 2016–2020. Public Health England, 2016.
56. Cashmore A W, Noller J, Johnson B, Richie J, Blinkorn A S. Taking the pain out of waiting: The oral health counselling experiences of parents of children with extensive dental caries. *Health Educ J* 2011; **70:** 407–419.
57. NHS Scotland. Childsmile – improving the oral health of children in Scotland Undated. Available at http://www.child-smile.org.uk/ (accessed January 2018).
58. Turner S, Brewster L, Kidd J *et al.* Childsmile: the national child oral health improvement programme in Scotland. Part 2: Monitoring and delivery. *Br Dent J* 2010; **209:** 79–83.
59. Macpherson L M, Anopa Y, Conway D I, McMahon A D. National supervised toothbrushing programme and dental decay in Scotland. *J Dent Res* 2013; **92:** 109–113.
60. Davies C, Harrison M, Roberts G. Guideline for the Use of General Anaesthesia (GA) in Paediatric Dentistry. London: Royal College of Surgeons, Faculty of Dental Surgery, 2008.

Official journal of the British Dental Association.