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Developing a population data linkage cohort to investigate the impact on child oral health outcomes following the roll-out of the Childsmile programme in Scotland

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Abstract

Background

Good oral health is essential for eating, smiling and talking, yet dental decay (caries) is amongst one of the most common diseases worldwide, with untreated caries in deciduous teeth affecting 9% of the child population at a global level. In high income countries, dental care has remained focused on treating oral diseases, rather than preventing them in the first place. Oral diseases predominantly affect the most socioeconomically deprived members of society and have strong links to the social determinants of health. In 2002, the Scottish Executive's consultation document '*Towards Better Oral Health in Children*' reported that by the age of three, 60% of children living in the highest areas of deprivation were suffering from caries and that more than half of five-year-olds across Scotland were also burdened by this disease.

In 2005, the Scottish Government published the national oral health and dental service strategy '*An Action Plan for Improving Oral Health and Modernising NHS Dental Services in Scotland*'. In response to the Action Plan, Childsmile, the national oral health improvement programme for Scotland was initially launched as demonstration projects in the West and East of Scotland and then rolled-out nationally during 2010 and 2011. Both the delivery and the evaluation of Childsmile was developed using theory- and evidence-based approaches. This combination led to the development of a multi-agency and multi-service programme that included the involvement of health visitors, specially trained community-based lay workers (Dental Health Support Workers), nurseries and schools (including supervised toothbrushing), as well as dental services (and the wider dental team).

Aim

The overarching aim of this thesis is to assess the impact of the measurable input at the individual child level of the Childsmile programme on the oral health outcome of 'obvious dental caries experience' of five-year-olds, taking into account socioeconomic deprivation. This aim will be met via answering the following research questions. (1) Is the Childsmile programme and its universal and targeted components being delivered as envisaged and does this differ by

socioeconomic status of the child population? (2) What is the association between obvious dental caries experience and sociodemographic characteristics (age, sex, and area-based deprivation) of the five-year-old study cohort? (3) What is the impact of each of the individual components of the Childsmile programme on obvious dental caries experience, and is there variation of the impact by sociodemographic characteristics? (4) What is the independent effect of each of the Childsmile components over and above the other interventions and the relative contributions of each of the components of Childsmile on obvious caries experience, within both the whole child population and for children living in the areas of highest deprivation?

Methods

The first challenge to be tackled in order to evaluate Childsmile in this way was to establish a series of linked and anonymised child level source datasets from multiple sources via a process of data management, quality and completeness checks, and then via data linkage, create a cohort that could capture the exposure to the components of Childsmile and be able to assess the impact on the oral health outcomes. There were two phases to this work due to the sheer complexity of the difficulties that presented themselves. Phase One was considered to be a pilot phase, and indeed was one of the national pilot projects that provided an early opportunity for the infrastructure of the National Safe Haven secure remote data linkage service in Scotland to be tested. The processes and learning not only informed the Childsmile evaluation, but also the wider methods of data linkage systems in NHS Scotland.

The development of the first phase towards creating the ultimate cohort included: i) successful navigation of the initial ethical and information governance approval processes for accessing and linking the source datasets that were to be used in the study; ii) identification of the appropriate datasets that were to be used in the evaluation of the outcomes of the Childsmile programme; iii) installation and pilot use of the National Health Service (NHS) National Service Scotland (NSS) electronic Data Research and Innovation Service (eDRIS) remote National Safe Haven infrastructure software; and iv) extraction and uploading of these datasets (including the initial linkage process) into the Safe Haven; and v) primary analysis of the datasets to measure and validate the data quality and completeness.

Phase Two consisted of: i) gaining updated consent to access and link multiple individual child level datasets to facilitate the outcome analysis of Childsmile; ii) using updated data linkage processes for the sharing and uploading of the refreshed source datasets into the Safe Haven; iii) further primary analysis of the datasets to measure and validate the data quality and completeness; and iv) initial primary analysis of the datasets to validate the linkage process, this step included developing comprehensive data dictionaries.

While the Childsmile Data Linkage project resource created included 24 datasets in total, the datasets that contributed to the final analysis cohort were: i) 'The 2009 Scottish Index of Multiple Deprivation' (SIMD) – which is an area-based socioeconomic measure; ii) 'Child Health Systems Programme Pre-School 6-8 Week Review' – which consists of proxy birth and population data; iii) 'National Dental Inspection Programme' (NDIP) – which provides data on child oral health outcomes; iv) 'Management Information and Dental Accounting System Treatments' (MIDAS) – primary dental care appointment data; v) Dental Health Support Worker (DHSW) contact datasets; vi) 'Toothbrushing Consent' – supervised nursery and school toothbrushing participation; and vii) 'Fluoride Varnish Visits' – nursery and school fluoride varnish applications. The datasets in the Safe Haven were validated using many different quality and completeness methods, including comparisons to published reports.

It was decided that in Phase Two, the year group with a 2014/2015 Primary One 'P1' (five-year-old) Basic NDIP dental inspection would be analysed. This was the most current NDIP year of inspection available at the time of this work and it was deemed to be appropriate as it was the first year group that had been born into the nationally 'rolled-out' Childsmile programme. The primary outcome for this work was the presence of 'obvious caries experience' in the Basic NDIP, which will be known in shorthand as 'Caries Experience'. There were 57,410 P1 NDIP individual child records in the 2014/2015 cohort year. After various exclusion criteria were applied, 50,379 children (88%) remained in the final study cohort, which remained representative of both the population and the oral health outcomes of the published 2014/2015 NDIP report. Overall, the quality and completeness of the datasets to be used in the study were high with no concerns highlighted when the completeness of the variables were checked (although this was not the case in Phase One). Of the 50,379 in the cohort, 30%

(n = 15,032) had Caries Experience. The four Childsmile components that were evaluated were: Dental Health Support Worker Contacts (‘DHSW Contacts’); Childsmile Contacts at a Dental Practice; Time Consented to Toothbrushing in the supervised nursery and school programme (‘Time Toothbrushing’); and Nursery and School Fluoride Varnish Applications.

Extensive statistical analyses were carried out. These included assessing whether or not the Childsmile programme was being delivered as envisaged, analysing the association between the potential confounders of age, sex, and SIMD (quintiles) with Caries Experience; the association between the Childsmile components and Caries Experience; the interactions between the Childsmile Components and the potential confounders; and the associations of the Childsmile components on Caries Experience after being individually adjusted for the potential confounders (Model One), and again after being adjusted for the potential confounders and the other three components (Model Two).

Results

The delivery of the programme was being delivered mostly as envisaged in terms of the targeted and universal components. However, there remains room to improve the reach of the components. The delivery of the universal supervised toothbrushing programme overall is high, with children from more deprived areas having slightly better participation.

The variable ‘DHSW Contacts’ has four categories: ‘Not Targeted’, ‘0 contacts’, ‘1 contact’, and ‘2 plus contacts’. The children who were targeted for a DHSW contact who did not receive a contact (‘0 contacts’) were the referent category for comparisons. The Model One results are provided as odds-ratios that are adjusted by age, sex, and SIMD (AOR). Those who were targeted and who received only one contact had 37% lower odds of Caries Experience than those who were targeted and not reached, AOR = 0.63; 95% CI (0.55 to 0.72), whereas those who had received two or more contacts did not have significantly lower odds than those targeted and not reached, AOR = 0.91; 95% CI (0.76 to 1.10). The effect of DHSW contacts on Caries Experience after the Model Two adjustment attenuated slightly but did not change the overall results.

The variable ‘Childsmile Dental Practice Contacts’ has eleven categories; ‘0 Childsmile contacts’, ‘1 contact’ … ‘9 contacts’ and ‘10 plus contacts’. Children with ‘0 Childsmile contacts’ at a dental practice were the referent category. Those attending ten or more times (two or more visits per year) experienced a 67% reduced odds of Caries Experience, AOR = 0.33, 95% CI (0.18 to 0.60), compared to those who never attended. There was no change in the effect of the Childsmile contacts at a dental practice after the Model Two adjustment.

The Childsmile component ‘Time Toothbrushing’ has four categories; ‘0 (no consent)’, ‘Up to 1 year’, ‘1 to 2 years’ and ‘2 plus years’. Each category represents a single year i.e. ‘Up to 1 year’ is one day to one year of toothbrushing consent prior to the NDIP inspection date. Children that were not participating in the supervised toothbrushing component, ‘0 (no consent)’, were the referent category. Compared to those who were not consented to toothbrushing, those who had participated in the toothbrushing component for two or more years had lower odds of Caries Experience, AOR = 0.81; 95% CI (0.76 to 0.87). There was a minimal strengthening of the effect of toothbrushing after the Model Two adjustment.

The variable ‘Nursery and School Fluoride Varnish Applications’ has seven categories: ‘Not Targeted’, ‘0 applications’ (the referent category), ‘1 application’, ‘2 applications’, ‘3 applications’, ‘4 applications’ and ‘5 plus applications’. For children that were targeted, the odds of Caries Experience decreased with an increasing number of fluoride varnish applications but was only significant with four or more applications (‘4 applications’ AOR = 0.89; 95% CI [0.82 to 0.96]). After the Model Two adjustment, there was no reduction in the odds of Caries Experience for this component (‘5 plus applications’ AOR = 0.99; 95% CI [0.91 to 1.08]).

There was a strong interaction (effect modification) between SIMD and the association between Time Toothbrushing and Caries Experience. For children living in the 20% most deprived areas of Scotland (SIMD 1) there was a reduction in the odds of Caries Experience for those children that had only been toothbrushing for one year (SIMD 1 AOR = 0.77; 95% CI = [0.64 to 0.93]) compared to those that had never been consented to toothbrushing, and with each additional year of Time Toothbrushing, the odds of Caries Experience reduced further. A similar but not so marked effect (AOR = 0.89; 95% CI = [0.72 to 1.09]) was observed for children living in SIMD 2 areas. After the Model Two adjustment, the strengthening of the effect of toothbrushing was strongest among children from SIMD 1. A weaker interaction between the number of Nursery and School Fluoride Varnish Applications and Caries Experience by Area Based-Deprivation (SIMD) was observed. Children living in SIMD 2 and 3 initially had a reduction in the odds of Caries Experience after five and four varnishes respectively, but the effect of this component was attenuated after the Model Two adjustment, and a reduction in the odds of Caries Experience was only observed for children living in SIMD 2 after receiving five or more varnishes (Model Two AOR = 0.80; 95% CI = [0.67 to 0.95]).

Conclusions

This thesis has shown that it was possible to create a study cohort via data linkage of routine administrative datasets and to undertake an initial evaluation of the impact of the components of the Childsmile Programme – which is a complex multifaceted national public health intervention - on the oral health of five-year-old-children.

The four main components of the Childsmile programme examined are largely being delivered as envisaged with respect to their differing targeted and universal aims, however, there remains room to improve the reach of aspects of the programme.

There was evidence to suggest that DHSW contacts were associated with a reduction in the odds of obvious caries experience when the child was contacted only once. This reduced risk disappeared if the child received additional contacts, which suggested that although there has been some success in DHSWs identifying children at a higher risk of obvious caries experience, the delivery of this component in terms of reducing the risk of caries for children at a higher need was less clear.

Attendance at a Childsmile dental practice was associated with a reduction in odds of obvious caries experience, with a clear dose response observed as the number of contacts increased and with no variation observed across the deprivation categories. It could be surmised that regular attendance at a dental practice may be a proxy for a positive approach to oral health within the family, and that the parents attending these contacts are already motivated or enabled towards caring for their child’s oral health. Moreover, no additional benefit of fluoride varnish application, over and above regular attendance at a dental practice, was seen in reducing the odds of caries experience.

Supervised toothbrushing was most effective at reducing the odds of dental caries when a child was living in an area of high deprivation, with the effect increasing the longer these children had been consented into the programme. For the children from the least deprived areas, there was no effect on the odds of caries experience observed regardless of the length of time that they had been participating in supervised toothbrushing.

The results of the analysis of the nursery and school fluoride varnish component show an initial independent effect, however, when those not contacted are taken into account, there is no overall effect, and reduced odds of developing caries only emerges among a very small number of children from SIMD 2 areas who received five or more fluoride varnish applications.

The findings of the thesis show differing risk associations between the various components of the programme and caries experience across area-based deprivation categories. This work has developed a resource, utilising nation-wide population routine administrative datasets, which can be used for further Childsmile evaluation. The findings can inform the future direction of the Childsmile programme and child oral health policy in Scotland.

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Author's Declaration

Parts of the research work included in this thesis have been presented in international and national conferences.

<u>National Conferences</u>

Childsmile Symposium 2018, 23rd January 2018, Glasgow, UK

Oral presentation title: Evaluation of Childsmile via Data Linkage.

<u>International Conferences</u>

25th Congress of the International Association of the International Association of Paediatric Dentistry, 1st-4th July 2015, Glasgow, UK

Poster presentation title: Childsmile National data linkage birth cohort: Scotland 2003-2012.

The Farr Institute International Conference, 26th-28th August 2015, St Andrews, UK

Poster presentation title: Establishing a linked database to evaluate Childsmile via the remote access National Safe Haven.

23rd Congress of the European Association of Dental Public Health, 18th-20th October 2018, Palma de Mallorca, Spain

Oral presentation title: Evaluation of Childsmile, Scotland's Child Oral Health Improvement Programme via Data Linkage

24th Congress of the European Association of Dental Public Health, 12th-14th September 2019, Ghent, Belgium

Oral presentation title: Association and Independent Effect of Individual Childsmile Interventions with Child Oral Health

I declare that, except where explicit reference is made to the contribution of others, the thesis is my own composition and has not been submitted in part or whole for any other degree.

Jamie Brian Rutherford Kidd
Glasgow - September 2019

Abbreviations

AOR:	Adjusted Odds Ratio
BASCD:	British Association for the Study of Community Dentistry
BMI:	Body Mass Index
CHS 6-8WR:	Child Health Systems Programme Pre-School 6-8 Week Review
CHSP-S:	Child Health Systems Programme – School Primary One Screening
COH:	Community Oral Health
d_1	caries at enamel level (deciduous teeth)
D_1	caries at enamel level (permanent teeth)
d_3	caries at dentine level (deciduous teeth)
D_3	caries into dentine level (permanent teeth)
dmfs	decayed missing and filled surfaces (deciduous teeth)
DMFS	decayed missing and filled surfaces (permanent teeth)
$d_3$mft	decayed missing and filled teeth (deciduous teeth)
D_3MFT	decayed missing and filled teeth (permanent teeth)
DHSW:	Dental Health Support Worker
ECC:	Early Childhood Caries
EDDN:	Extended Duty Dental Nurse
eDRIS:	electronic Data Research and Innovation Service
EPCC:	Edinburgh Parallel Computing Centre
EPR:	Electronic Patient Records
FV:	Fluoride Varnish
HB:	Health Board

HEAT:	Health improvement, Efficiency, Access to treatment, and Treatment
HIC:	Health Informatics Centre
HVCRA:	Health Visitor Caries Risk Assessment
ISD:	Information Services Division
MIDAS:	Management Information and Dental Accounting System
NDIP:	National Dental Inspection Programme
NHS:	National Health Service
NSS:	National Services Scotland
PAC:	Privacy Advisory Committee
PAF:	Population Attributable Fraction
PBPP:	Public Benefit and Privacy Panel
ppm:	parts per million
OR:	Odds Ratio
SIGN:	Scottish Intercollegiate Guidelines Network
SIMD:	Scottish Index of Multiple Deprivation
SMR01:	General / Acute Impatient and Day Case – Scottish Morbidity Record
TAU:	Treatment as usual

Chapter 1 - Introduction

‘Oral Health at a tipping point’ screams the editorial headline of The Lancet in the summer of 2019 which has promoted a Lancet Series, led by prominent dental public health figures including Professor Richard Watt, a Scottish born dentist and current Chair of Dental Public Health at University College London in the Department of Epidemiology and Public Health, and Professor Lorna Macpherson, Professor of Dental Public Health and lead of the Community Oral Health Section and Research Group at the University of Glasgow, and co-Director and Evaluation Lead of Childsmile. Professor Watt stated that ‘the mouth really is a marker of people's social position and future disease risk … and oral diseases are a canary in the coal mine for inequality’ (Davies, 2019). Good oral health is essential for eating, smiling and talking, yet dental decay is amongst one of the most common disease worldwide, with untreated caries in deciduous teeth affecting 9% of the child population at a global level (Peres et al., 2019). In high income countries, dental care has remained focused on treating oral diseases, rather than preventing them in the first place (Watt et al., 2019) despite evidence that oral diseases predominantly affect the most socially deprived members of society and have strong links to the social determinants in health (Peres et al., 2019). Radical changes are required to bring dentistry into the wider health care system if the needs of the population rather than the individual are to be met (Watt et al., 2019). Childsmile, Scotland’s national oral health improvement programme launched in 2006, is a concerted attempt to improve child oral health and reduce inequalities, both in dental health and in access to dental services in Scotland (Macpherson et al., 2019b).

1.1 Literature Search Strategy

Ovid Medline and Embase were formally searched for relevant literature using the terms ‘early childhood caries’, ‘obvious caries experience’, ‘public oral health’, ‘public health programmes’, ‘complex intervention evaluation’, ‘oral health promotion’, ‘oral health improvement’, ‘preventive dentistry’ and other related terms. In addition, Google Scholar and Pubmed were also searched. The bibliographies of any relevant papers were also checked to identify additional papers that could be used in the narrative review, as were papers which citied those already identified. Google was also used to identify grey literature and relevant government and health services policy documents. Discussions were had with Childsmile programme staff and members of its evaluation team to identify reports and audits that were not publicly available.

1.2 Definition of Dental Caries

Dental caries, also simply known as caries, is defined as the 'chemical dissolution of a tooth surface brought about by metabolic activity' (Kidd and Fejerskov, 2016), which explains the more common term 'tooth decay' (Featherstone, 2008). It is a non-communicable disease (World Health Organisation, 2017). Featherstone (2008) pessimistically stated that dental caries is often still regarded as 'holes in the teeth' by non-dental and dental professionals alike, as opposed to a complete disease process. This is despite it being scientifically established for over a century that dental caries is the result of bacteria acting as a catalyst in the fermentation of carbohydrates – especially free sugars in the mouth, which in turn produces acids that dissolve minerals in and around teeth. Enamel caries in the outer level of the tooth is the first stage of caries which results in 'white spots' developing on the surface of the tooth (Selwitz et al., 2007). Dentine caries is caries in the deeper dentine layer of the tooth and is more severe than enamel caries (Conway et al., 2014). Dental caries within pre-school children, defined as Early Childhood Caries (ECC), is now considered a distinct condition (Tinanoff and O'sullivan, 1997). Previously the presence of caries in pre-school children had been attributed to feeding habits via a baby bottle but it is now widely recognised to be the result of multiple influences including regular sugar consumption (Tinanoff et al., 2019).

The effect of poor oral health should not be underestimated. Macpherson et al. (2019a), state that poor oral health can severely impact on an individual's quality of life, especially if one cannot eat, speak, or smile without a feeling of discomfort or embarrassment. Children as young as five have self-reported oral health as having a negative impact on their daily lives, mostly related to eating, but with sleeping and smiling also a concern for them (Tsakos et al., 2012). Furthermore, the presence of dental caries during childhood sets a marker for later in life, not just for continued poor oral health but also for general health. There are some, albeit limited data showing that the level of childhood dental caries experience goes on to reflect caries experience in adulthood as reported in a small Norwegian cohort study (Skeie et al., 2006). Factors such as childhood socioeconomic status and parental attitudes towards dentistry create a chain effect that influences toothbrushing and dental attendance during childhood, which in turn impacts oral health behaviours into early adulthood, which then reflects the level of dental caries in adulthood (Broadbent et al., 2016).

1.3 Epidemiology of Dental Caries in Children

The epidemiology of dental caries – especially among children – has been extensively reviewed (Marthaler, 2004; Selwitz et al., 2007; Conway et al., 2014; Frencken et al., 2017).

These reviews cover the epidemiological measurement of caries and describes the burden of the disease in different populations.

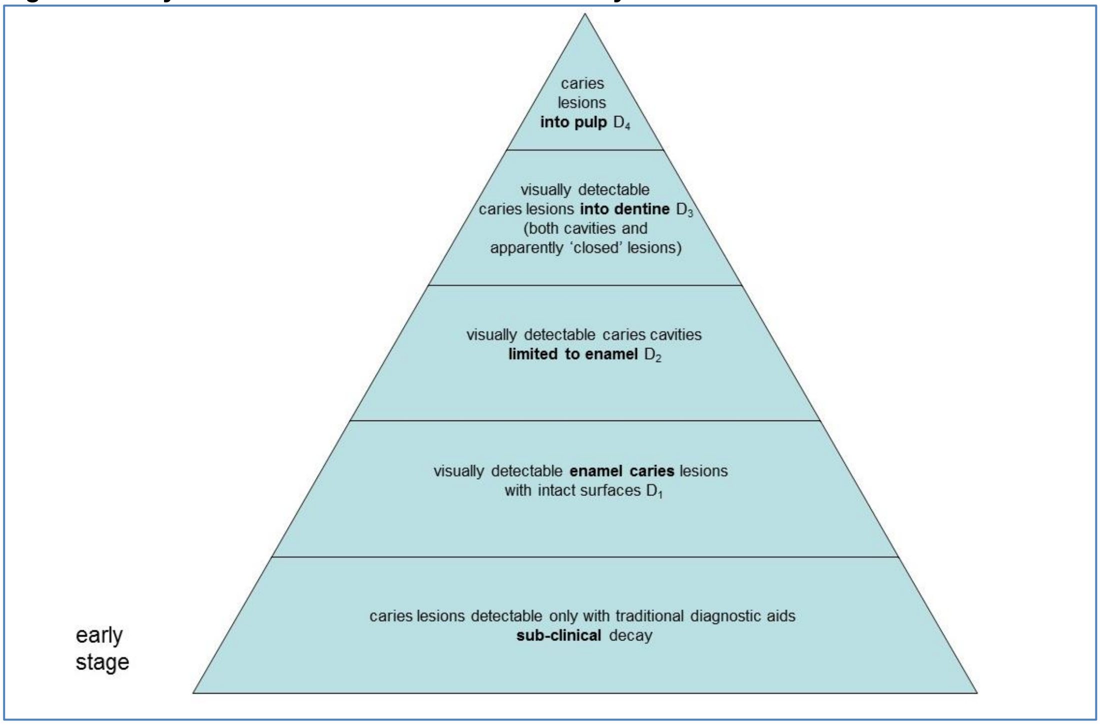
1.3.1 Measurement of Caries in Children

The British Association for the Study of Community Dentistry (BASCD), which sets the guidelines for epidemiological surveys of dental health in the United Kingdom, defines the primary measurement of dental caries as decay into the dentine. These dentinal caries lesions are recorded following visual clinical inspection – examination with the naked eye under standard lighting, without the use of a dental probe, compressed air, transillumination or radiographs (Ismail, 2004; Pitts et al., 2007). This is caries at the visually 'obvious' level. Obvious caries experience (also referred to as obvious decay experience) is measured by the DMFT index (lower case dmft for deciduous teeth), including decayed teeth (d_3 or D_3), plus missing ('m' or 'M') teeth (as a result of an extraction due to caries) and filled ('f' or 'F') teeth, and is routinely referred to as $d_3$mft in deciduous teeth (Macpherson et al., 2010b) and D_3MFT in permanent teeth (Merrett et al., 2009). As caries at the d_3 and D_3 level does not include caries at the enamel (d_1 and D_1), it will provide lower instances of caries than when measured either at the d_1 and D_1 level (Pitts and Fyffe, 1988) or when diagnostic instruments are available (Pitts and Evans, 1997).

In deciduous teeth, the maximum $d_3$mft score is 20 and in permanent teeth there is a maximum D_3MFT score of 32 which includes wisdom teeth (Kidd and Fejerskov, 2016). Kidd and Fejerskov also described a second index of caries measurement: decayed, missing and filled surfaces (dmfs and DMFS). This index records the presence of caries on each surface of a tooth (eighty-eight surfaces in deciduous teeth and one hundred and forty-eight in permanent teeth). There are some limitations to the decayed, missing and filled indices (tooth and surface): they assume all missing teeth are the result of caries rather than other reasons e.g. trauma; the weighting of decayed, missing or filled teeth is all the same, therefore a person with five missing teeth and a person with five carious teeth will have the same score even though they both may have completely different levels of oral disease (Daly et al., 2002).

Tooth-level dentinal dental caries remains the predominant threshold used in epidemiological surveys (Morgan and Monaghan, 2017; Macpherson et al., 2018; Public Health England, 2018). Due to the possibility of subclinical (not visually obvious decay) being present, the traditional term ‘caries free’ is increasingly being replaced with ‘no obvious decay experience’ (Selwitz et al., 2007). Figure 1-1 demonstrates the various thresholds of dental caries diagnosis. Thus, ‘no obvious decay / caries experience’ or its converse ‘obvious decay / caries experience’ are the primary epidemiological measurements used to describe the disease prevalence in populations (Conway et al., 2005)

Figure 1-1: Pyramid of thresholds of dental decay



(Adapted from Pitts., 2001)

1.3.1.1 Dental Epidemiological Methods in Scotland

Between 1987 and 2002, the *Scottish Health Boards' Dental Epidemiological Programme* (SHBDEP) was responsible for the surveillance of the prevalence of dental caries of children attending local authority schools in Scotland (Scottish Health Boards' Dental Epidemiological Programme, 2002). In 2003, SHBDEP was replaced by the *National Dental Inspection Programme* (NDIP) which continues to the present date (Scottish Dental Epidemiological Co-ordinating Committee, 2003; Macpherson et al., 2018).

NDIP is an annual survey that has two levels. The first level is a 'Detailed Inspection' that alternates yearly in the collection of $d_3$mft data of Primary One children (five-year-olds) and of D_3MFT data of Primary Seven children (11-year-olds) enrolled in local authority schools in Scotland (Merrett et al., 2005). The Detailed NDIP is a representative sample of the age-group-population (Watkins and Pitts, 1994) sampling around 20% of the school-year-group population. The Primary One (P1) sampling ranged from a low of 16% in 2004 (Merrett et al., 2004) to a high of 28% in 2014 (Macpherson et al., 2014).

The second level of NDIP is the 'Basic Inspection', an annual survey which includes every child in Scotland in both P1 and Primary Seven (P7) classes attending local authority schools (Scottish Dental Epidemiological Co-ordinating Committee, 2003). The 2003 inspection was piloted in the National Health Service (NHS) Lanarkshire health board for P1 children only but was rolled out nationally for both P1 and P7 in 2005 with national data publicly available from 2007 onwards (Merrett et al., 2007). It is a population-wide dental health assessment of five and 11 year olds, and the proportion of P1 children that received a Basic Inspection ranged from a low of 84% in 2007 (Merrett et al., 2007) to a high of 92% in 2012 (Macpherson et al., 2012). The Basic Inspection is 'a simple assessment of the mouth of the child using a light, mirror and ball-ended probe' (ISD Scotland, 2015). The outcome of the Basic Inspection is that one of three letters is issued to the parent / carer of each child informing them of their child's oral health status and advising them of the dental treatment requirements for their child (ISD Scotland, 2015). Although the wording of these letters has changed in recent years, in 2015, the NDIP cohort year this thesis will eventually focus on, the three letters were:

- Letter A - should seek immediate dental care on account of severe decay or abscess.
- Letter B - should seek dental care in the near future due to one or more of the following: history of tooth decay, a broken or damaged front tooth, tooth wear, poor oral hygiene, or may require orthodontics.
- Letter C - no obvious decay experience but should continue to see the family dentist on a regular basis.

These data are also used for local planning purposes and have been used as part of community child health profiles (Scottish Public Health Observatory, 2018). The NDIP datasets are collated, analysed, and stored nationally in NHS National Services Scotland Information Services Division (ISD). They are held in an identifiable format and have a potential for secondary analysis and data linkage research.

Thus far epidemiological analysis has utilised the detailed NDIP inspection data at the aggregated level for ecological epidemiological analyses (Blair et al., 2013; Blair et al., 2015).

A recoding of the criteria used to issue the letters is required to identify children with obvious caries experience and those without, which would include all of the ‘C’ letters along with some of the ‘B’ letters (Brewster et al., 2013). As all children with ‘C’ letters will remain coded as being without obvious caries experience (and with little variation expected in the percentage of those with no obvious caries experience after recoding), using ‘C’ letters alone as a measure, the results of the P1 Basic Inspections closely reflect that of their corresponding Detailed Inspections (Table 1-1). It can therefore be concluded from these series of surveys that regardless of the level of NDIP inspection used, there is little to no difference in the oral health outcome (no obvious caries experience).

Table 1-1: Comparison of Obvious Caries Experience of five-year old Children in Detailed and Basic National Dental Inspection Programme Results by Year of Report

	No Obvious Caries Experience	
Year	**Detailed**	**Basic**
2008	58%	58%
2010	64%	63%
2012	67%	66%
2014	68%	67%

Sources: (Merrett et al., 2008; Macpherson et al., 2010b; Macpherson et al., 2012; Macpherson et al., 2014)

1.3.2 Child Dental Caries Globally

Worldwide, dental caries is ranked as the most widespread non-communicable disease (World Health Organisation, 2017). The *2015 Global Burden of Disease Study* reported that over 2.4 billion people worldwide have dental caries in their permanent teeth, an increase of 15% over the previous decade, and that there are approximately 490 million children with dental caries in their deciduous teeth, which increased over the same time period by 7% (Vos et al., 2017). Although dental caries has traditionally been most prevalent in the Americas and Europe and lowest in Africa, it is expected that dental caries will rise in Africa due to an increased consumption of sugars coupled with insufficient access to preventive treatments and interventions (World Health Organisation, 2003). Marthaler (2004), in a review of dental caries trends in Western countries from 1953 to 2003, identified a substantial decline in child dental caries prevalence from the 1970s and through the 1980s, which he related to the introduction and widespread uptake of fluoridated toothpaste. However, by 1990, this decline had begun to slow, and prevalence levels have plateaued.

According to the *2003 World Oral Health Report* that gathered data from cross-sectional surveys from around the world, the general global trend of caries prevalence was declining in ‘developed’ (high income) counties and rising in ‘developing’ (low and middle income) countries during the 1980s and into the 1990s (Petersen, 2003). These trends can potentially be explained in the context of the global trends in exposure to risk factors for dental caries (high-sugar diets) and to the protective factors (fluoride). Low-middle-income countries are shifting to the diets of high-income countries with high sugar consumption which is impacting on increasing population levels of caries. Since the 1960s, high income countries have increasingly adopted caries protective measures – particularly the use of fluoride toothpaste (and in some countries water fluoridation), which has had an effect of reducing caries levels overall (Petersen, 2003).

1.3.3 Child Dental Caries in the United Kingdom

The oral health of children in the United Kingdom has improved over the last four decades (National Statistics, 2004). In 1983, 50% of five-year-old children in the United Kingdom had no obvious caries experience and this had increased to 57% by 2003. However, there was a variation in the proportions of children with no obvious caries experience across the four regions of the United Kingdom with 59% in England (Harker and Morris, 2005), 49% in Northern Ireland (Harker and Nuttall, 2005), 48% in Wales (Harker and Chestnutt, 2005) and 45% in Scotland (Scottish Dental Epidemiological Co-ordinating Committee, 2003).

1.3.4 Child Dental Caries in Scotland

In 1983, only 24% of five-year-olds in Scotland had no obvious caries experience (Pitts and Davies, 1988). By 1988, there had been a vast improvement in oral health with 42% of five-year-olds having no obvious caries experience (Merrett et al., 2006). This rose slightly to 45% in the 2003 inspection but the overall trend in improvement was starting to plateau (Scottish Dental Epidemiological Co-ordinating Committee, 2003).

At the beginning of the twenty-first century, Scottish five-year-old children had the worst oral health in the United Kingdom and also among the worst in Europe (Scottish Dental Epidemiological Co-ordinating Committee, 2003). For example, a study of the dental health of 200 five-year-olds from eight different European countries in 1993/1994 reported that only 38% of the children in Scotland had no obvious caries experience in comparison to 46% in Ireland and 74% in Sweden (Bolin et al., 1996). The 2003 NDIP report also reported that Scottish five-year-olds had among the worst oral health in Western Europe, and which was on par with many Eastern European countries (Scottish Dental Epidemiological Co-ordinating Committee, 2003). The report also compared individual health boards to the rest of Europe. Scottish health boards located in areas of lower deprivation by Scottish standards, compared favourably. In contrast, health boards such as Greater Glasgow and Argyle & Clyde, traditionally deprived areas of Scotland, had a much higher burden of caries and compared poorly.

The Scottish Executive's published document *Towards Better Oral Health in Children* (2002) reported that by the age of three, 60% of children living in the highest areas of deprivation were suffering from caries and that more than half of five-year-olds across the country were also burdened by this disease. This resulted in over a quarter of a million teeth being extracted from children per year, with this procedure being the most common reason for children in Scotland to receive a general anaesthetic.

1.3.5 Inequalities in the burden of Child Dental Caries

The prevalence of children with no obvious caries experience is not equally distributed across the population – rather, there are inequalities both within and between counties and populations (Conway et al., 2014). This has been comprehensively reviewed recently (International Centre for Oral Health Inequalities Research & Policy, 2015; Peres et al., 2019). These inequalities are dominated and driven by socioeconomic factors, but also relate to other sociodemographic factors such as ethnicity and urban / rural factors (Conway et al., 2014). Within Scotland, these inequalities can be observed. A small study from Glasgow, comparing the oral health of five-year-old children from ethnic minority groups to their white contemporaries, found that the caries experience of children of Pakistani ethnicity was almost double that of white children, even after adjusting for area-based socioeconomic deprivation (Conway et al., 2007). Five-year-old children living in Scotland's four largest cities also appear to have worse oral health than children living in rural environments (Levin et al., 2010). In 2014, the year before the study cohort received their Basic Inspection, the Detailed Inspection of five-year-old children reported that just under half of children living in the most deprived areas in Scotland have obvious caries experience in comparison to just 17% in the areas of least deprivation (Macpherson et al., 2014) as measured via the area-based Scottish Index of Multiple Deprivation (SIMD). These results are not unique to Scotland and are reflected across countries traditionally referred to as ‘developed’ such as the United States of America (Dye et al., 2010).

The extent of socioeconomic inequalities in child dental health in Scotland has also been analysed in detail (Blair et al., 2013), and this analysis is also now adopted within routine NDIP reports (Macpherson et al., 2018). It can be observed that absolute inequalities, measured by the Slope Index of Inequality (Regidor, 2004), are substantial between the most and least deprived (Macpherson et al., 2018).

1.4 Risk Factors / Determinants for Child Dental Caries

Traditionally, biological and behavioural (proximal) factors have dominated the literature in relation to risk factors and determinants associated with child dental caries. These include: the presence of oral cariogenic bacteria in the mouth; dietary factors such as the presence of high levels of free sugars; levels of exposure to fluoride; and saliva composition and tooth structure (Macpherson et al., 2019a). However, the authors state that it is now understood that many biological and behavioural factors are influenced by the circumstances in which people grow, live and work and that a social determinants of health approach is required to understand the ‘causes of the causes’ in terms of oral health and oral health inequalities. More recently, the spotlight has also been shone on commercial determinants and the deliberate and negative influence the sugar industry can have on oral health policy worldwide (Peres et al., 2019).

The following sections will briefly discuss the traditional biological risk factors before focussing on the more current and relevant social determinants of child oral health.

The literature on risk factors for dental caries in children has been extensively appraised in several narrative reviews (Murray et al., 2003; Chestnutt, 2016) and in a recent systematic review and meta-analysis (Kirthiga et al., 2019). Kirthiga and colleagues (2019) found 89 studies that identified 123 risk factors that could broadly be grouped into five main categories: oral bacteria; dietary; oral hygiene; sociodemographic; and ‘other’ factors.

1.4.1 Biological Risk Factors

1.4.1.1 Oral Cariogenic Bacteria

The presence of microbial biofilms on the tooth surface is a requirement for caries development. Historically, much emphasis was placed on the role of the mutans streptococcus group of bacteria, since animal studies had demonstrated high cariogenicity due to the ability of these bacteria to produce and tolerate an acidic environment. Consequently, many studies investigating risk factors for caries concentrated on the identification of these specific bacteria from plaque biofilms. Not surprisingly, therefore, a strong association has been seen between levels of mutans streptococci and caries. This is borne out in the findings of the systematic review of Kirthiga et al. (2019), where the risk factor with the greatest association with ECC was the presence of mutans streptococci. However, it is now hypothesised that caries develops when there is an ecological disturbance of the overlying plaque biofilm. This can occur, for example, following exposure to sugars which in turn can lead to an overgrowth of many species of plaque bacteria (including mutans streptococci) which can produce acid and survive in an acidic environment (Marsh et al., 2015).

1.4.1.2 Diet and Sugar

The evidence that free sugars in the diet are a prerequisite for caries development comes from many study types. These include studies of plaque pH following the metabolism of sugars by bacteria in the microbial biofilm, both in animal studies, and cross-sectional and longitudinal studies in humans. There have been very few human intervention studies, due to the difficulties in manipulating the diet over a prolonged period, and there have been methodological quality issues associated with such studies (Chestnutt, 2016). In 2014, a systematic review was published which updated the evidence in relation to the association between the amount of sugar intake and dental caries in children and adults (Moynihan and Kelly, 2014). Overall, the quality of the evidence was described as moderate, due in part to the historical nature and types of studies included in the review. Nonetheless, the authors reported a consistency of the data over time, supporting the relationship between the amount of sugar consumed and the development of caries. There was moderate quality evidence showing lower levels of caries when free-sugar intake is below

10% energy, with some evidence (classified as very low quality) indicating a benefit of restricting free sugar intake below 5% energy.

Moynihan (2016) has discussed the relative importance of the amount and the frequency with which sugars are consumed and stated that both are important. She endorses upstream approaches focussing on the amount of sugars in relation to caries and the wider non-communicable diseases, while suggesting that the more downstream, individual patient-focussed advice in the dental setting should cover the importance of limiting both the amount and frequency of free sugars intake.

1.4.1.3 Oral Hygiene

The systematic review by Kirthiga et al. (2019) reported that visible plaque and toothbrushing less than once daily were the two most important oral hygiene factors related to ECC, and a systematic review by Mejàre et al. (2015) cited high quality evidence to support the reduced risk of ECC caries with regular toothbrushing. Additionally, a recent small pragmatic study (Boustedt et al., 2019) into toothbrushing habits for children found that the relative risk for caries at five years of age was significantly increased for 'tooth brushing less than twice daily' at two and three years of age. Almost all children (98%) were using a fluoride-containing toothpaste. A critique of this study is that the relationship between twice-per-day toothbrushing and socioeconomic status was not reported.

A recent systematic review (Hujoel et al., 2018) assessed the association between personal oral hygiene and dental caries in the absence of the confounding effects of fluoride. The authors concluded that such a regime, i.e. in the absence of fluoride, failed to show a benefit in terms of reducing the incidence of dental caries.

Thus, while toothbrushing can play a role in disrupting the plaque biofilm, the evidence points to the presence of fluoride in the toothpaste as having the major caries preventive effect.

1.4.1.4 Exposure to Fluoride

Fejerskov et al. (2015) have stated that caries should not be considered the result of fluoride deficiency. However, the fluoride ion can have a major, topical caries-reduction effect on biofilm-covered tooth surfaces in the oral cavity. For this to occur, the fluoride ion should be present in the oral fluids at slightly elevated levels for prolonged periods during the day.

There are a number of ways in which fluoride can be delivered into the oral cavity. Vehicles include water, toothpaste, milk, rinses, drops and tablets, as well as those more dependent on clinical interventions such as fluoride varnish and gels (Chestnutt, 2016).

Over the years, there have been many systematic reviews conducted to investigate the caries reduction effects of the various methods of delivering fluoride to the oral cavity. Many of these have been Cochrane systematic reviews.

This literature review will focus briefly on fluoride varnish and fluoride-containing toothpaste as these are the fluoride delivery vehicles used in the Childsmile programme.

A Cochrane systematic review of fluoride varnish (FV) application was published in 2003, and updated in 2013 (Marinho et al., 2003; Marinho et al., 2013). The updated review concluded that FV reduced worsening of caries in the deciduous dentition with a prevention fraction of 37%, 95% CI 24%-51%, $p<0.0001$. The evidence included in the review was deemed to be of 'moderate' quality.

However, emerging evidence questions the effect of fluoride varnish applications in the prevention of caries, particularly when used in conjunction with other oral health interventions and in the age group which is particularly relevant to the Childsmile programme. Recently, a systematic review of fluoride varnish and dental caries in pre-schoolers has been published (de Sousa et al., 2019). This review included clinical trials of fluoride varnish either alone or as part of a combined intervention, and compared fluoride varnish application with placebo, usual care or no intervention. The review included 20 trials, with 17 included in a meta-analysis. The pooled relative risk at the individual level was 0.88 (95% CI 0.81; 0.95). The authors concluded that FV application in pre-school children showed a modest and uncertain anti-caries effect. They stated that cost-effectiveness analyses were needed in different populations and application settings to determine whether FV should to be adopted and/or continue to be used by dental services.

A Cochrane systematic review (Marinho et al., 2003) investigated the evidence in relation to fluoride toothpastes for preventing dental caries in children and adolescents. Seventy-four studies were included in the review with 70 contributing data for meta-analysis. The pooled prevented fraction was 24% (95% CI, 21 to 28%; $P < 0.0001$). The trials included in the review were deemed to be of relatively high quality, but there was little information available concerning the deciduous dentition. The overall conclusion was that the studies provided clear evidence that fluoride toothpastes were efficacious in preventing caries.

A very recently published Cochrane systemic review of studies that compared the effect of different strengths of fluoride toothpaste (Walsh et al., 2019), reported that, for the deciduous dentition, brushing with 1500 part per million fluoride (ppm F) toothpaste reduced the risk of dental caries when compared to a toothpaste containing no fluoride. When comparing levels of fluoride in the toothpaste, the effect of 550 ppm and 1500 ppm were similar, whereas there was a slight reduction in dmfs when toothbrushing with 1450 ppm F compared to 450 ppm F. However, only a small number of studies were available to the reviewers for comparing the concentrations of fluoride in toothpaste regarding caries prevention within the deciduous dentition. It is therefore difficult to draw a strong conclusion, and further research comparing the effect of different concentrations of fluoride in toothpaste on the deciduous dentition is required to help strengthen public health policy and advice in this area.

1.4.2 Socioeconomic Risk Factors

Clear social gradients in dental health have been apparent for some time among different population groups. A recent paper by Peres et al. (2019) highlights that in the last few years some papers have shown, using quasi-experimental methods, causal relationships between dental health and socioeconomic status. The authors also summarise the findings of systematic reviews and a small number of longitudinal studies exploring socioeconomic position and caries experience over the life course. All show an association between indicators of socioeconomic status and dental health.

Much thought has therefore been given as to why such stark oral health inequalities occur so that appropriate approaches and actions can be developed to tackle these inequalities (Watt et al., 2015).

The World Health Organisation (WHO) produced a social determinants framework (Solar and Irwin, 2010) that has been adapted by Watt and Sheiham (2012) into a conceptual model for oral health inequalities (Figure 1-2). These models highlight the influence that structural factors, such as political and economic drivers within a country, can have on individuals and communities (Yevlahova and Satur, 2009). Such factors include rates of taxation and social and welfare policies, including the availability of universal health care, income support and state pensions (Solar and Irwin, 2010).These structural factors can influence the circumstances in which people live and work, and determine their socioeconomic status within societies.

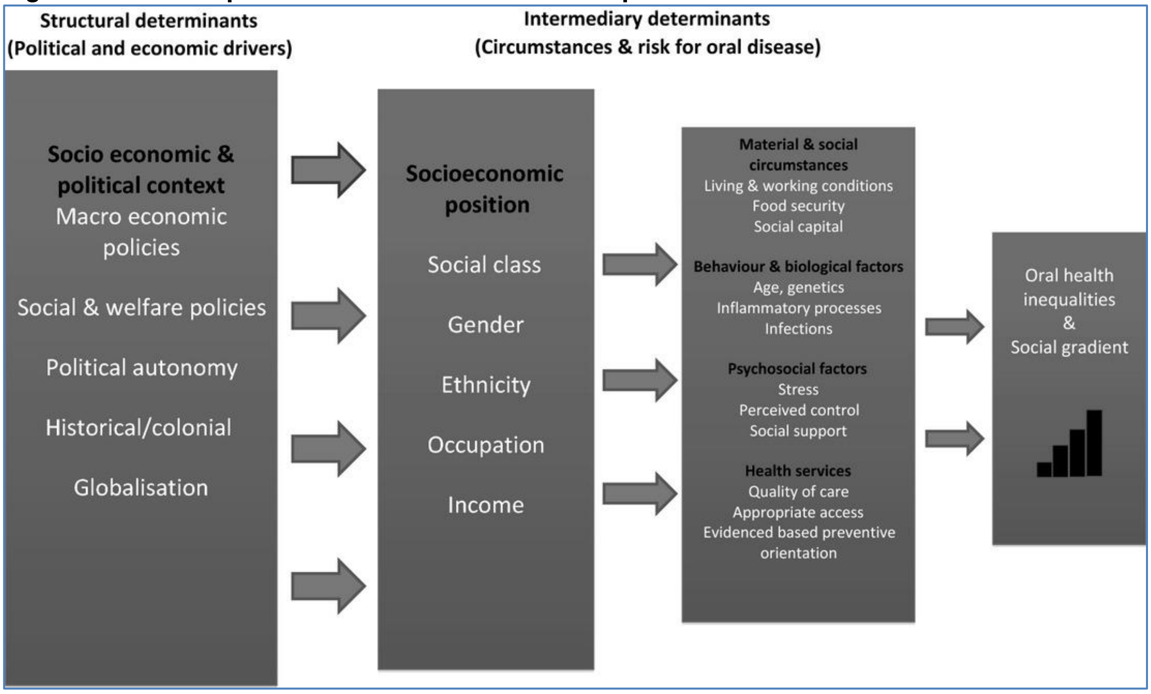
These circumstances are intermediate factors within the framework and include housing and working conditions, availability of health and social services, access to healthy foods, neighbourhood conditions, and psychosocial factors such as stress and social support. These factors can, in turn, influence the more proximal biological and behavioural factors such as the immune system and behaviours such as smoking, alcohol consumption, diet and physical exercise levels. Thus, a network of factors are all interacting and influencing one another, creating complex models of the social determinants of health (Newton and Bower, 2005). Exposure to these intermediate inequalities and health influencing factors can be the means by which socioeconomic status creates health inequalities (Solar and Irwin, 2010).

1.4.3 Commercial Determinants of Health

Commercial determinants of health have been defined as ‘strategies and approaches that are used by the private sector to promote products and choices that are detrimental to health’ (Kickbusch et al., 2016). Hastings (2012) believes that this is as an important determinant of health as social determinants.

The influence of the sugar industry has been observed at the structural level, for example, politicians have been lobbied to oppose reports and policy that would be detrimental to the sugar industry (McKee and Stuckler, 2018). This influence has also been extended to the research sector where industry funds and promotes research which can move the emphasis of the research community away from public health strategies (Fabbri et al., 2018). An investigation by Kearns and Bero (2019) reported a systematic downplaying of the role of sugar in dental caries. This was claimed to be due, in part, to the corporate sponsorship of dental research organisations that market sugary confectionary and drinks. The authors argue that research has been funded by the sugar industry to drive the focus away from sugar and dietary risks and more towards research on non-dietary intervention such as vaccines to prevent caries (Kearns et al., 2015).

Figure 1-2: Conceptual Model for Oral Health Inequalities



Extracted from Watt and Sheiham (2012)

The commercial determents of health are also influential at the intermediate level (Peres et al., 2019); individuals may not have the resources to purchase healthy food and therefore purchase unhealthy but affordable food and drinks high in sugar (Blecher et al., 2017) which are often tailored and targeted towards individuals of low socioeconomic status (Peres et al., 2019).

1.4.4 Multiple and Clustered Risk Factors

The concept of common risk factors was first defined by Sheiham and Watt (2000). They postulated that some of the risk factors associated with dental diseases (diet, smoking and alcohol consumption) are not unique to these diseases, but rather are shared by other chronic diseases such as obesity, heart disease and cancer.

The concept of clustering of risk factors is also now understood. A population-based study that analysed data from the 2003 Scottish Health Survey identified that risk factors in Scotland related to chronic diseases (including dental caries) are generally not isolated, but rather they tend to be clustered within the population and are strongly related to socioeconomic deprivation (Lawder et al., 2010). Smoking, alcohol consumption, lack of fruit and vegetable consumption, obesity and lack of physical exercise were all considered risk factors common to chronic diseases. Persons living in the most deprived areas in Scotland were more than twice as likely to have three risk factors and more than three times as likely to have four of five risk factors, compared to those living in the most affluent areas.

Thus to tackle chronic diseases, both common risk factor and multifaceted approaches are required to target a whole host of risk factors, with a particular focus on socially-disadvantaged persons or communities where there is a greater prevalence of risk factors (Macpherson et al., 2019a).

Watt (2012) emphasised the importance of developing new and innovative approaches to challenge oral health inequalities, and that different approaches to what has previously been undertaken may be required. He further specified that reductions in oral health inequalities are more achievable if a multidisciplinary population-based public health approach is undertaken.

1.5 Oral Health Interventions

The WHO social determinants framework has been used to develop approaches to address the social determinants of health inequalities (World Health Organisation, 2008). This framework outlines the requirement for multifaceted interventions that simultaneously engage at the structural ‘upstream’ level (e.g. government policies relating to housing, education, welfare, taxation and income to create a more equal society); the intermediary ‘midstream’ level (e.g. at a community level); and the individual ‘downstream’ level. For oral health, Watt states that this requires different stakeholders working together (e.g. policy makers, dental professionals and community leaders) to develop innovative interventions, and to ensure there is an appropriate dissemination of the knowledge and skills required to deliver change (Watt, 2012).

1.5.1 Upstream Approach

In 2007, Watt challenged the oral health community to move from a ‘victim blaming’ downstream approach to one that acknowledged the need for more upstream action to tackle the social determinants of oral health inequalities. He highlighted the causal pathways linking the biological, behavioural, psychosocial, environmental and political factors to oral health outcomes and inequalities. Furthermore, he provided examples, including those based in the field of tobacco control, which highlighted the greater value and effectiveness of upstream fiscal policies and environmental regulations compared with those based on behavioural and clinical preventive measures. The paper also provided practical examples of local and national upstream actions to promote oral health. These included measures such as the development of oral health and nutrition policies in nurseries and schools; development of oral health appropriate infant feeding policies; supporting regulations on the content of television advertisements promoting children’s foods and drinks; and encouraging tighter legislation on food labelling. Health professionals, including dentists, have been providing health advice on sugar reduction to the public for years, yet the effect of this advice has been minimal (Macpherson et al., 2019a). It has therefore again been emphasised that novel upstream methods are drastically required in this area (Watt et al., 2019). Concerning the prevention of childhood caries, WHO supports a combined approach that incorporates initiatives to tackle childhood obesity and promote breastfeeding (World Health Organization, 2017). Upstream initiatives that tackle common risk factors include the promotion of healthy eating and a reduction in the consumption of foods high in sugar which can take the form of the taxation of sugary drinks, and legislation of the marketing of unhealthy produce towards children (Macpherson et al., 2019a). It is predicted that the taxation of drinks high in sugar will have a positive impact on child oral health (Briggs et al., 2017).

1.5.1.2 Water Fluoridation

The fluoridation of water supplies is considered an effective upstream approach for reducing dental caries at a population level (McDonagh et al., 2000). However, a landmark Scottish legal case in 1980, Mrs Catherine McColl against Strathclyde Regional Council (Oldham, 1985) ruled in favour of Mrs McColl on the grounds that the Council did not have the authority to introduce fluoride into the public water supply. This essentially halted the plans of dental public health practitioners in Scotland to introduce fluoride to the national water supply at that time and therefore alternative methods for the delivery of fluoride at the community level were sought. This position was further and more recently confirmed in the Scottish Executive consultation *Towards Better Child Oral Health* (Scottish Executive, 2002) where there was a large anti-water fluoridation response.

1.5.2 Midstream and Community Approaches

Midstream approaches attempt to mitigate against the effects of structural determinants of health that can influence social position and circumstances. They often involve strengthening at-risk communities against the social and environmental factors that local residents can encounter on a daily basis.

Community development approaches can be an effective mode of engaging with the most deprived communities (O'Mara-Eves et al., 2013; Brunton et al., 2014; Brunton et al., 2015). Community co-designed programmes that involve multiple stakeholders such as health professionals, teachers, community groups, the voluntary sector, parents, and other members of the community have the potential to improve oral health in traditionally deprived communities (Huebner and Milgrom, 2015). The involvement of as many of these stakeholders as possible at each stage of a programme, i.e. design, implementation and monitoring, has been shown to provide positive outcomes (National Institute for Health and Care Excellence, 2016). This approach enforces the idea that it is working with communities, rather than designing programmes for them that will have the most positive results. The development of positive relationships between all stakeholders is essential, as are early conversations related to power, decision-making authority and responsibility (O'Mara-Eves et al., 2013).

Macpherson et al. (2019a) have summarised some of the benefits of oral health initiatives engaging and working with existing community schemes in a socioeconomically disadvantaged area. These partnerships have the potential to facilitate families with skills and knowledge in areas such as self-empowerment, resilience and financial budgeting, as well as gaining practical experience in areas such as cooking on a low budget, and increasing access to healthy foods, social networks of support, and health and social services. Oral health can be incorporated into existing health services including antenatal classes, weaning clinics and universal early year health checks. Such clinics can provide ideal settings to distribute free or discounted toothbrushes and toothpaste.

Public Health England (2014) has reviewed the evidence relating to community-based interventions to improve child oral health that could be commissioned by local authorities in England. In addition to some of the interventions outlined above, nurseries and schools were identified as appropriate settings to provide targeted supervised toothbrushing and fluoride varnish programmes. Additionally, the toolkit identified initiatives such as healthy food and drink policies in childhood settings.

An excellent and relevant example of a midstream community-based approach is an oral health *Pre-5-Year-Old Oral-Health-Gain Project* that was piloted in a very socially deprived neighbourhood in Glasgow, Scotland with a history of poor levels of ECC in 1998 (Blair et al., 2004). Early results were so promising that it empowered community members from a comparative neighbourhood to adopt their own 'informal health promoting activities'. As a result of this, the local health board formally expanded the intervention into this second neighbourhood. Dental Public Health professionals worked alongside community representatives including 'parents, carers…, community volunteers, lay representatives, statutory agencies, charities and the local business sector' to identify potential behaviours within the community that could be modified to bring about positive oral health changes. Multiple interventions were delivered, such as the introduction of toothbrushing with fluoride toothpaste in nurseries, breakfast and after-school clubs, distribution of fluoride toothpaste and toothbrushes in welfare locations accessed by parents, and working with pre-existing social and community networks such as churches, libraries, community events and local health centres. There were significant reductions in the mean dmft of nursery-aged children in the initial pilot area after the four-year intervention. Interestingly, in the comparative neighbourhood, there was an increase in mean dmft during the first two years of the programme (prior to it joining) but the opposite was observed two years later, once it had become part of the programme. This programme was a prime example of approaches that could be adapted to suit local social and environmental factors such as strengthening and utilising communities to promote health and wellbeing as per the Ottawa Charter (World Health Organisation, 1986). The programme was subsequently expanded across all of the most deprived communities in Glasgow, with similar positive results observed (Blair et al., 2006).

1.5.3 Downstream Approach

Systematic reviews of interventions targeted at the individual level, such as the clinical prevention of caries and oral health education within the dental practice setting, have identified that these preventive methods only have a limited impact on improving oral health and, in fact, can widen oral health inequalities (Yevlahova and Satur, 2009). Oral health education, in particular, has been highlighted as having the potential for increasing inequalities (Macintyre, 2007). This is because families of higher socioeconomic status are more able and, consequently, more likely to engage with and adopt educational messages than families of lower socioeconomic status. Therefore, before health professionals can deliver effective oral health promotion, they must understand the conditions and factors influencing the daily lives of the people they see and develop 'a supportive environment that is conducive to promoting oral health' (Macpherson et al., 2019a).

It has therefore been suggested that delivery of chairside oral health education that takes a blanket approach, not tailored to an individual's needs, is an ineffective model for providing both long-lasting oral health improvement and tackling the social determinants of poor oral health (Yevlahova and Satur, 2009).

It is also long-established that those with the greatest need for oral health care are the least likely to access this support. This is known as the 'inverse care law' (Hart, 1971).

The role of dental practitioners, however, should not be down-played. They are often the first point of contact families may have with primary care providers, and can therefore have an important role to play in challenging social determinants of health, both oral and the wider determinants, due to shared common risk factors (Williams et al., 2013).

A paper by Watt et al. (2014) provides practical examples of how members of the primary care dental team can promote oral health equity for both their own patients and the wider community. This includes workforce training and education to ensure that team members understand the concepts of the social determinants of health and that exposure to most risk factors is inversely related to social position. Key skills include communication, advocacy and taking full social histories to enable appropriate linking of patients to local community agencies to support complex issues faced by families related to issues such as social welfare and debt. The need for ensuring equity of access to dental services and provision of evidence-based health improvement advice and clinical prevention are also outlined in the paper.

The WHO Ottawa Charter (1986) as well as the Scottish Government (Scottish Government, 2016a) have recognised the requirement of refocusing health services towards preventing rather than treating diseases if health inequalities are to be challenged.

First published in 2010 and updated in 2018, the Scottish Dental Clinical Effectiveness Programme has issued evidence-based guidance for the prevention and management of dental caries for children in the dental practice environment. The aims of the guidance included keeping children caries free, and to create an environment where children grow up with a positive attitude towards oral health and their personal oral health skills. To achieve this, the guidance suggested that dental practitioners should: encourage parents to take leadership over their child's oral hygiene at home; deliver a range of caries-preventive measures with a focus on preventing rather than treating caries; and signpost families to support services that can help with specific needs, if the dental team member identifies additional requirements for support that falls out with their remit. The clinical prevention outlined in the guidance promotes the use of fissure sealants and fluoride varnishes. The importance of the promotion of toothbrushing and sugar reduction are also emphasised, as are the requirements of tailoring these non-clinical approaches to suit the needs of individual families.

1.6 Oral Health Policy in Scotland

1.6.1 Action Plan

In 1999 the Scottish Executive re-set the target of 60% of five-year-old children in Scotland to have no obvious caries experience, which was originally set for

2000, to be achieved by 2010 (Scottish Executive, 1999). In 2002, a national consultation on approaches to improve child oral health was conducted (Scottish Executive, 2002). In response there was a large anti-water fluoridation campaign mounted – evidenced in the volume of responses and with 97% of those responding being against fluoridation of public water supplies. This meant that water fluoridation was ruled out as part of the national strategy and did not even reach a debate and vote in the Scottish Parliament. In 2005, the Scottish Government published the national oral health and dental service strategy *An Action Plan for Improving Oral Health and Modernising NHS Dental Services in Scotland* (Scottish Executive, 2005). The plan detailed both the financial and overall approach that would be provided for child oral health improvement and which subsequent Scottish government administrations have all unilaterally supported (Macpherson et al., 2019a).

1.7 Childsmile

1.7.1 The Founding Principles of Childsmile

In response to the Action Plan, *Childsmile*, the national child oral health improvement programme for Scotland was initially launched as demonstration projects in the West and East of Scotland (Macpherson et al., 2010a; Turner et al., 2010). The building blocks for Childsmile were a combination of the public health principles for reducing health inequalities laid out in the Ottawa Charter (World Health Organisation, 1986), and the then current evidence from systematic reviews and clinical guidelines (Scottish Intercollegiate Guidelines Network, 2005).

1.7.2 Evidence Based Preventive Interventions

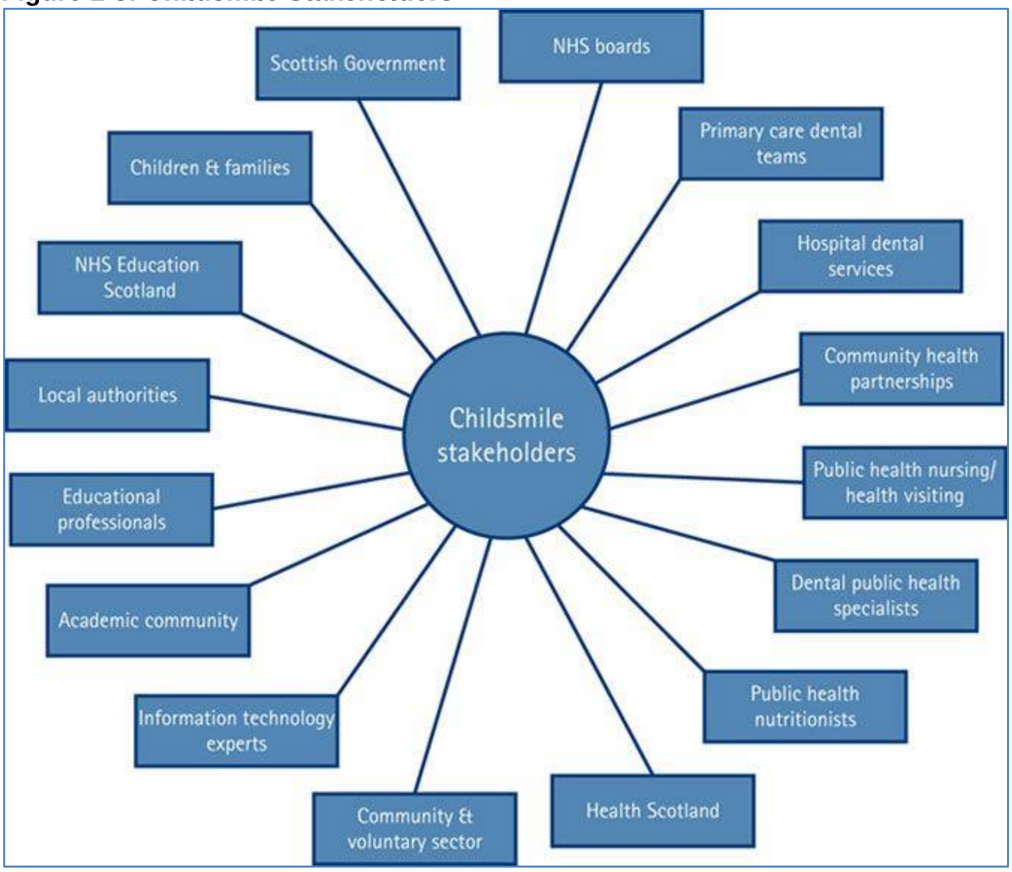
Childsmile built on the knowledge gained from prior oral health interventions delivered in Scotland. This included clinical interventions offered in dental practices (Donaldson et al., 1986), community-led programmes that included engaging with local populations, community knowledge and skills development, the distribution of fluoride toothpaste and toothbrushes (Blair et al., 2004; Blair et al., 2006) and health visitor identification of high risk children and provision of oral health advice (Ballantyne-MacRitchie, 2000).

1.7.3 Theory Based Development

Both the delivery and the evaluation of Childsmile were developed using theory- and evidence-based approaches (Macpherson et al., 2019b). This method of development specifies what the mechanisms of change are at the start of a programme (i.e. the Childsmile interventions) and the context in which these will be provided (Blamey and Mackenzie, 2007). This approach involved a wide range of stakeholders (Figure 1-3) which assisted in the identification of evidence-based interventions that could provide long-lasting positive changes to outcomes related to child oral health (Macpherson et al., 2019b).

The combination of an evidence and theory-based approach led to the development of a multi-agency and multi-service programme that included the involvement of health visitors, nurseries and schools, community-based support workers and agencies, as well as dental services (Macpherson et al., 2010a).

Figure 1-3: Childsmile Stakeholders



Extracted from (Macpherson et al., 2010b)

1.7.4 Aims of Childsmile

The overarching aims of Childsmile were to not only improve the overall dental health of children living in Scotland, but to also tackle the inequalities observed in Scotland in terms of oral health outcomes and accessing general dental services (Macpherson et al., 2010a). This involved the refocussing of dental services more towards preventive care and engaging with children from a young age (Wright et al., 2015), working within and with communities, and delivering clinical prevention and oral health promotion initiatives in nurseries and schools (Turner et al., 2010). The Childsmile interventions are a mixture of targeted interventions (focussing on children predicted to be at higher risk of dental caries) and universal interventions available to all children, but the with ability to tailor the intensity of the intervention to suit the needs of the individual child, termed ‘proportionate universalism’ in the 2012 Marmot Review (Marmot and Bell, 2012).

Shaw et al. (2009) acknowledged that although Childsmile could anticipate those children who faced the burden of health inequalities, Childsmile alone could not address the social determinants of these inequalities. A much greater social and political upheaval would be required: ‘reform efforts to improve health inequalities must be intersectoral and not just focused on the traditional health sector’ (Shaw et al., 2009).

1.7.5 Childsmile Components

Childsmile is a complex, multi-sectoral intervention, using public health principles (World Health Organisation, 1986) such as the common risk factor approach, upstream, midstream and downstream initiatives and proportionate universalism. It also draws on evidence from systematic reviews (O'Mara-Eves et al., 2013; Brunton et al., 2014; Brunton et al., 2015) and clinical guidelines (Scottish Intercollegiate Guidelines Network, 2014).

There are four main components of Childsmile: the community-based intervention involving Health Visitors, Dental Health Support Workers and other community-based groups; the dental primary care component, where members of the dental team provide preventive clinical treatment alongside tailored dietary and toothbrushing advice; the supervised toothbrushing programme where children are offered free daily supervised toothbrushing in nurseries and school; and the application of fluoride varnish to the teeth of children in nurseries and schools, in establishments targeted by levels of socioeconomic deprivation (Macpherson et al., 2019b).

In 2006, two Childsmile demonstration projects, initially scheduled to be undertaken for three years, were launched in the East and West of Scotland (Macpherson et al., 2010a). At the end of the demonstration phase, a process to roll-out all of the Childsmile components across the whole of Scotland was undertaken and, by 2011, it was operating as a fully integrated programme within all fourteen health boards in Scotland (Macpherson et al., 2019b).

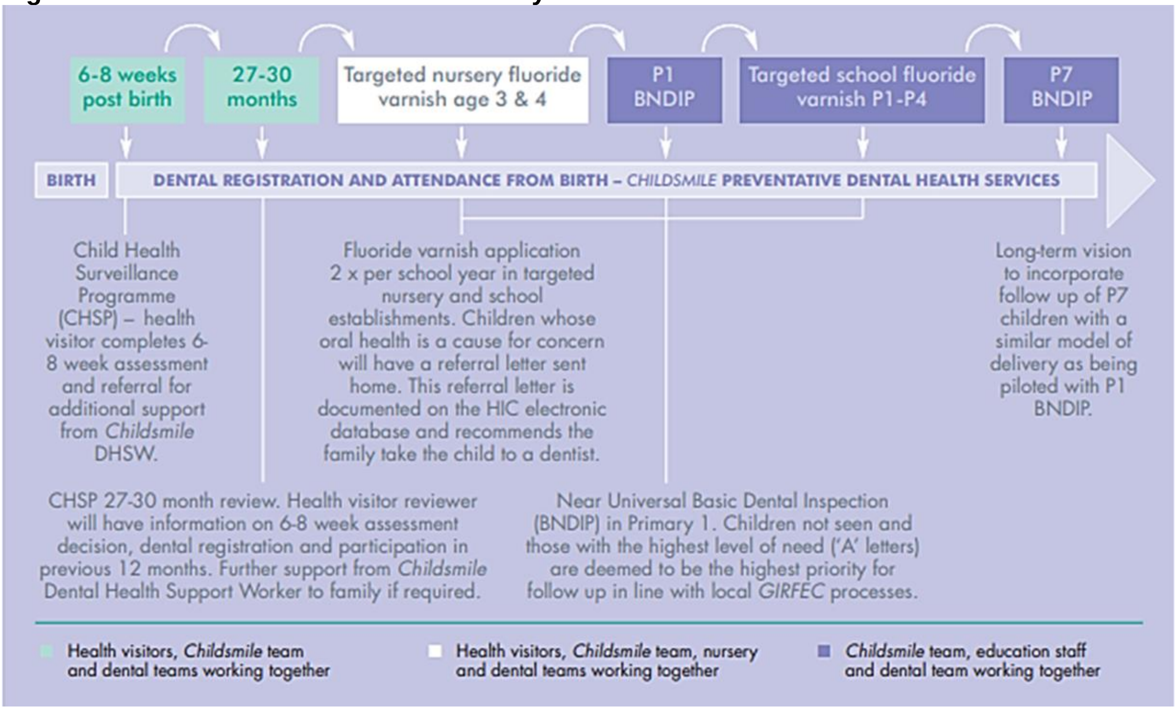
The Childsmile oral health pathway (Figure 1-4) begins when the child is six to eight weeks old, with children being thereafter exposed to the different components at different stages of their pre-school years. A dental inspection occurs when the child is aged five, when they are in the first year of primary school (P1). For some children, supervised toothbrushing and fluoride varnish applications continue in targeted primary schools. Provision of advice and clinical prevention in dental primary care should continue throughout childhood.

Outwith the four main components, Childsmile also supports policy change at the upstream national level, for example, representatives of the programme formed part of a multidisciplinary group which was successful in developing healthy eating regulations for schools (Scottish Government, 2008). The formal incorporation of Childsmile into the universal child health surveillance system in Scotland (see 1.7.5.1) and the reorientation of the NHS primary care contract (see 1.7.5.2) also provide examples of more upstream activity.

1.7.5.1 Dental Health Support Workers

The benefits of utilising Health Visitors, specially trained nurses who universally visit parents with new born children throughout Scotland, in identifying children at increased risk of dental caries had previously been established (Ballantyne-MacRitchie, 2000). Training members of communities to provide oral health advice, toothbrushes and fluoride toothpaste within areas of high deprivation in Scotland has also shown positive outcomes (Blair et al., 2004; Blair et al., 2006) Capitalising on this research, within Childsmile, every child in Scotland is first linked to Childsmile via the child health surveillance programme as part of the Universal Health Visitor Early Years Pathway (Scottish Government, 2015b). Families are regularly contacted by Health Visitors from when the child is six- to eight-weeks-old, up until they are five years of age (Macpherson et al., 2019b). These contacts by the Health Visitor allow them to monitor the child’s health and development, as well as offering health advice and signposting to an array of different services (Scottish Government, 2015b). Childsmile is formally integrated into the child health surveillance programme, with specific guidance available to health visitors on appropriate dental advice, relative to the age of the child. There is the opportunity to dispense Dental Packs containing toothbrushes and fluoride toothpaste, and to promote the attendance of children from a young age at a dental practice (Macpherson et al., 2019b). Health Visitors also identify families who they feel may require additional support in relation to the oral health of the child and refer these families to local community-based Dental Health Support Workers (Turner et al., 2010).

Figure 1-4: Childsmile Oral Health Pathway



Extracted from (Macpherson et al., 2015)
CHSP – Child Health Surveillance Programme; DHSW – Dental Health Support Worker; GIRFEC – Getting it Right for Every Child; P1 – Primary One; P7 Primary 7.

Dental Health Support Workers (DHSWs) are Childsmile-funded community-based lay workers (Hodgins et al., 2018). DHSWs are embedded within areas of high deprivation and offer peer support to families with young children within the family home as well as at community clinics (Macpherson et al., 2019b). DHSWs offer age-specific oral health interventions (dietary and toothbrushing advice and the distribution of dental packs containing toothbrushes and fluoride toothpaste) at the home of the family (and at community clinics), and help facilitate attendance at an NHS dental practice ('High Street Dentist') or Public Dental Services clinic (to be referred to collectively as a 'dental practice'), delivering Childsmile interventions (Kidd, 2012). DHSWs tailor the level of support required for each child depending on the individual needs of the family. For example, a DHSW may deem it necessary to visit a family more than once before facilitating attendance at a dental practice. They may also assess the family / child as requiring additional support from them, to complement their attendance at a dental practice.

DHSWs should also interact with local community agencies and third sector organisations and can signpost and facilitate engagement with these local supportive organisations. DHSWs can work alongside these services to help embed oral health into their activities (Macpherson et al., 2019b).

1.7.5.2 Childsmile Dental Practice

From July 2006 to September 2009, dental practices participating in the Childsmile demonstration programme in the West of Scotland were remunerated for their involvement in the programme directly from Childsmile. In October 2011, Childsmile was introduced into mainstream NHS Scotland dentistry, with remuneration payments undertaken via the Statement of Dental Remuneration, the contract by which NHS dentists are paid for their services (Scottish Government, 2011b). This essentially meant that Childsmile was now available in every NHS dental practice in Scotland that offered paediatric services and led to the re-orientation of primary dental care to be more preventive focused.

Children, along with their parents or carers, are invited to attend a dental practice on a regular six-monthly basis, commencing during the child’s first year of life. Age-specific oral health interventions are offered which should be tailored to the individual needs of the child. The specific interventions which now attract an NHS fee are fluoride varnish application from the age of two years, and toothbrushing and dietary advice. These interventions can be delivered by any member of the dental team who is considered trained and competent in relation to these activities. This includes Extended Duty Dental Nurses.

Emphasis is placed on moving away from the standardised ‘health education’ messages delivered in the practices and towards more individual focused and tailored messages instead. Action plans should be developed jointly by the dental team member and the family. The approach requires the dental team to understand the social and commercial determinants that may act as barriers to families implementing the preventive approaches within their home, and to be aware of local organisations and groups that they can direct the families to when their needs lie outwith the scope of the care the dental team can provide (Watt et al., 2014).

1.7.5.3 Supervised Toothbrushing in Nursery and School

Towards the end of the 20th century, nursery toothbrushing programmes started operating in various parts of Scotland. In 2001, a standardised national toothbrushing programme was established with the toothbrushes and toothpaste provided by the Scottish Executive, via a national procurement contract. This programme was assimilated into the wider Childsmile programme in 2006 (Macpherson et al., 2013a). National standards have been produced and local dental teams train nursery staff to adhere to these standards (Scottish Dental Clinical Effectiveness Programme, 2010). This midstream activity is universally available to every three- and four-year-old child attending nursery (both local authority and private). By 2007, 95% of nurseries in Scotland were participating (Anopa et al., 2015). Supervised toothbrushing is also available in targeted primary schools using the same method of targeting as the fluoride varnish programme (see below) (Macpherson et al., 2019b). In both nurseries and participating primary schools, children are given the opportunity to brush their teeth, under the supervision of nursery or school staff, for a minimum of two minutes per day with 1,000 ppm fluoride toothpaste (1,450 ppm since Autumn 2016). Children are also provided with a home pack containing a toothbrush and fluoride toothpaste on at least four occasions while at nursery, with the aim of encouraging toothbrushing in the home (Macpherson et al., 2019b).

1.7.5.4 Fluoride Varnish Applications in Nursery and School

Initially trialled in the East of Scotland, fluoride varnish applications are targeted towards children aged three- to eight-years-old attending nurseries and schools within the most deprived areas of each of the fourteen Scottish health boards (Humphris and Zhou, 2014). At least 20% of children living in each of the health boards are targeted for this intervention (Macpherson et al., 2019b). Nurseries and schools are targeted in order of those with the highest proportion of children living in the most deprived SIMD quintile within each health board.

Evaluation of the efficiency of targeting of the programme by Brewster et al. (2013) showed that to ensure that children from the most (20%) deprived SIMD areas are included in the programme, nursery schools located in the three most (60%) deprived SIMD fifths needed to be included in the programme. The intervention involves the application of fluoride varnish to the teeth twice per year by Extended Duty Dental Nurses trained in the application of fluoride varnish (Macpherson et al., 2019b). This process also allows for the identification of children who need further dental care within a dental practice.

The Extended Duty Dental Nurses, functioning in both primary dental care and the nursery / school setting all receive formal training from NHS Education for Scotland.

1.7.6 The Evaluation of Childsmile

1.7.6.1 Review of literature on evaluating complex public health interventions

Pawson et al. (2005) have stated that simple experiments can be relatively easily designed to evaluate an individual treatment. Public health intervention programmes, however, are often multi-agency and multi-setting and are therefore considered complex interventions. These can be difficult to develop and monitor, and are often non-transferable due to the context-specific nature of the intervention (Campbell et al., 2000). Due to their complexity, there is no ‘one-size-fits-all’ or gold standard approach for evaluating complex interventions and the gold standard randomised control trial is not always possible, feasible or appropriate. Instead, a variety of evaluations methods are required (Minary et al., 2019).

An up-to-date review of methods, outwith individual randomised control trials, used in the evaluation of complex interventions was undertaken by Minary et al. (2019). They summarised that the various methods are not always mutually exclusive and combined method approaches can be used, depending on the nature of the programme / intervention.

A pragmatic trial allows one intervention to be paired against another to measure the same outcome (Treweek and Zwarenstein, 2009) and it is particularly beneficial at the onset of a complex intervention as it can provide the programme developers with a comprehensive knowledge of resources required to deliver an intervention (Patsopoulos, 2011). However, a criticism applied by Minary et al. (2019) is that although a pragmatic trial can provide an overview of the effectiveness of an intervention, within a multi-component intervention, it is not always possible to clarify which component explains the observation.

Another example of an adapted randomised control trial is a cluster randomised control trial where groups of participants, such as children attending the same school, rather than individuals, are randomly assigned to an intervention (James et al., 2004). Cluster trials allow for interactions between persons within a cluster to be considered to measure the 'group effect' (Minary et al., 2013) although there is a risk of bias should every participant in the cluster not take part in the intervention (Hahn et al., 2005). Further limitations of the cluster randomised control trial include the risk of the 'cluster effect', when participants within a cluster share too similar characteristics thus effectively reducing the sample size or when there are distinct differences in the individual characteristics between clusters (Hahn et al., 2005).

The stepped wedge cluster randomised control is an alternative style of cluster trial described by Hemming et al. (2015). These clusters can take the form of a geographical area i.e. for the roll-out of a national intervention. At the onset, none of the clusters are assigned to the intervention. The first cluster (or group) is randomly assigned to the intervention. This process is repeated at regular intervals until all the clusters have started the intervention. The end of the evaluation will be after all the clusters have been exposed to the intervention for a period of time. Data are collected for each cluster when they are in the control and in the intervention. This method is particularly suitable for evaluating interventions that do not require participant recruitment such as a national public heath intervention programme.

As complex interventions are often context specific, the interpretation of the effect of an intervention does not provide an understanding of how the effect is interacting with the environment of the study (Minary et al., 2019). Therefore, to assist the analysis, a mixed methods approach that includes an analysis of the processes unique to the environment of the study can be undertaken (Moore et al., 2015). This qualitative approach 'aim[s] to examine the views of participants on the intervention; study how the intervention is implemented; distinguish between components of the intervention; investigate contextual factors that affect an intervention; monitor dose to assess the reach of the intervention; and study the way effects vary in subgroups' (Oakley et al., 2006). An additional benefit of this approach highlighted by Oakley et al. is that it allows researchers to differentiate between whether an intervention was poorly designed at the onset or if it was the programme itself that was ineffective.

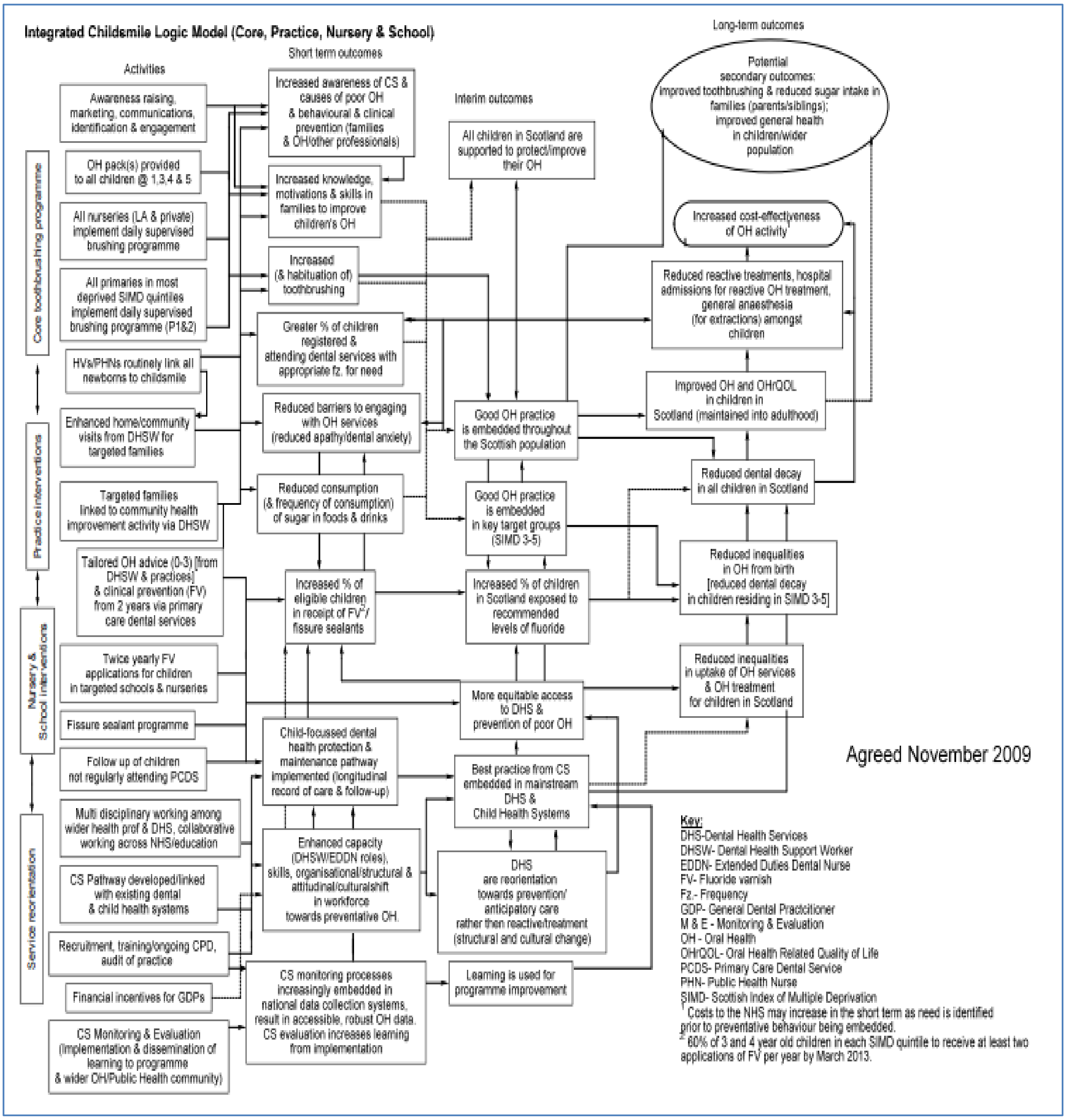
Natural Experiments are quasi-experimental and non-experimental studies (Minary et al., 2019). These are normally in the format of an observational study where variations in the delivery or the exposure of the intervention in different areas are not decided by researchers, but instead are naturally decided (Craig et al., 2012). An example of this was when the association between the roll-out of the national Childsmile nursery toothbrushing programme (initiated at different times in different NHS boards) and a reduction in dental caries in a Scotland-wide population study was investigated (Macpherson et al., 2013a).

The Scottish Executive decided to implement the Childsmile demonstration programmes across all relevant health boards (East or West) at the same time and, again, the Scottish Government took the same approach with the roll-out of the whole programme to all areas of Scotland in 2010/2011. This therefore limited the opportunity to design some of the methodological approaches described in the previous paragraphs, but as outlined above, some natural experiments were carried out.

1.7.6.2 Childsmile Logic Model

The evaluation of Childsmile, and indeed the programme itself, was conceived using a 'theory-based approach' i.e. a logic model (Figure 1-5) was designed in the context of the Scottish geo-political environment. It identified and utilised 'evidence-based health improvement activities and approaches' and linked these to outputs and interim outcomes and to long-term outcomes. These latter outcomes included measures of oral health and oral health inequalities (Macpherson et al., 2019b). Multiple stakeholders were involved in the logic model development process. The logic model not only guides both programme development and delivery, but also the process and outcome evaluation. For example, to measure if the activities (of the Childsmile components) are being delivered as envisaged, short term and interim outcomes (outputs of the programme) are measured, via the routine monitoring of the programme (Central Evaluation & Research Team, 2018). If they are not being delivered as envisaged, theory-based qualitative work can be undertaken to determine potential barriers and facilitators. Once these are known, the ways the activities are being delivered can be amended. This 'Theory of Change' approach thus investigates if the programme is being delivered as intended, and the long-term outcomes of the programme can also be evaluated.

Figure 1-5: Extract from the Childsmile Logic Model



Extracted from (Childsmile, 2010)

1.7.6.3 Childsmile Evaluation

The evaluation of Childsmile therefore focuses on both process evaluation (to measure and optimise programme delivery as intended), and the longer-term outcomes of the programme, related to aspects such as health, health inequalities and cost-effectiveness.

1.7.6.4 Process Evaluation

Process evaluations are essential to know not just 'if' an intervention is working, but to understand why it is working (Moore et al., 2015). For Childsmile, the process evaluation is a mixed methods approach that involves examining the routine monitoring data concerning the reach and uptake of each of the components of the programme. This includes: rates of fluoride varnish in nurseries and schools, as well as in dental practices; dental participation and registration rates; participation in the supervised toothbrushing programme, and DHSW and Health Visitor activity (Macpherson et al., 2019b). These data can be obtained via the annual Childsmile Headline reports (Central Evaluation & Research Team, 2018), ISD statistics on NHS dental registration and participation (ISD Scotland, 2018a), and unpublished nursery and school toothbrushing surveys. If required, qualitative research is undertaken to identify factors which may help to enhance the future provision of activities. Thus, process evaluation supports the ongoing refinement of the programme (Macpherson et al., 2019b). An example of this mixed methods approach has been the use of quantitative data to capture differences in the delivery of the DHSW roles across regions and the consequent development of qualitative studies to better understand the barriers and facilitators of the various roles so that the overall delivery of the programme by DHSWs can be optimised (Young, 2017).

1.7.6.5 Outcome Evaluation

The outcome evaluation of Childsmile involves a number of different study designs. These include ecological and natural experiments, a randomised control trial, a population-level cohort study and health economic evaluations. Many of these study types involve linkage of routinely collected health and education data with bespoke Childsmile data.

The innovative data linkage project is described in detail throughout this thesis. It involves the linkage of multiple datasets to form a series of study cohorts.

These cohorts can be either prospective e.g. a birth cohort, or retrospective e.g. where the children already have the outcome, such as an NDIP inspection result.

Examples of studies conducted using the different study designs are outlined below.

1.7.6.6 Ecological Analysis

An ecological analysis measured the association between the roll-out of the supervised toothbrushing across Scotland and the results of the NDIP programme, which had been demonstrating a general reduction in mean $d_3$mft since 2004 (Macpherson et al., 2013a). A significant correlation was observed at national level between the start date and subsequent rate of roll-out of supervised toothbrushing in each health board area and the slope of the reduction in mean $d_3$mft over time. The results of the study were based on the percentage of nurseries participating in the programme and did not measure the effect of the exposure time individual children had with the supervised toothbrushing programme.

1.7.6.7 Cost Analysis

An economic evaluation of the supervised toothbrushing programme, which was a follow up to the study above, was conducted (Anopa et al., 2015). The cost analysis study explored the association between the annual costs related to the implementation of universal nursery toothbrushing within the Childsmile programme and the estimated annual dental treatment costs of children over the same period. The research showed that the nursery toothbrushing programme was associated with a major improvement in the dental health of five-year-old children in Scotland whilst also generating significant cost savings to the NHS through ‘avoided’ treatments. Over the first ten years of the universal toothbrushing programme, the estimated cost savings increased each year. The largest savings were associated with children living in the highest areas of deprivation. It was concluded that the nursery toothbrushing programme represented a ‘win-win’ scenario with gains in child oral health outcomes, cost savings and a reduction in health inequalities.

1.7.6.8 Randomised Control Trial

An embedded randomised control trial (Wright et al., 2015). was undertaken to compare the effect of fluoride varnish applications in nurseries over and above ‘treatment as usual’ i.e. the other components of the programme, including supervised toothbrushing, with ‘treatment as usual’. Three-year old children were randomised to the intervention (FV + TAU) or comparison group (TAU) with the intervention group receiving fluoride varnish applications every six months in the nursery setting between baseline and 18 months. Dental inspections were undertaken at baseline and after two years. A total of 1303 children were randomised, leading to 1150 evaluable children (n=577 FV, n=573 TAU, with 12% dropouts). The preliminary results found only a modest reduction in the worsening of $d_3$mft in the FV + TAU group over the two year period in comparison with the TAU group (Wright et al., 2018).

1.7.6.9 Cohort Study

The majority of the Childsmile evaluation work discussed in this section has been limited to either data collected ‘in-house’ by the Childsmile programme or aggregated data supplied by external bodies. The Childsmile logic model (Figure 1-5) sets out several long-term outcomes including improvements in oral health and reductions in oral health inequalities. It is essential that when evaluating Childsmile outcomes, that the effect of each of the Childsmile components in relation to the outcomes is understood. This is not possible using just the ‘in-house’ and / or aggregated data, as the depth of data required for this evaluation is not available within these sources. Much of the data relating to the Childsmile components are held by bodies outwith Childsmile, as are the data that could be used to measure the Childsmile outcomes. Therefore, individual child level data are required from a range of different sources that can be brought together via data / record linkage so that a population-level cohort study can be undertaken.

Data linkage from these sources has been used to build a retrospective cohort of the five-year old population, with similar start and end dates, where each member of the cohort has had, in theory, the same level of opportunity to participate in Childsmile.

1.8 Data / Record Linkage

1.8.1 Definitions and Origins

The *Oxford Dictionary* online (2019) defines record linkage as 'the process of combining items of information or sets of data that relate to the same subject'. The term 'record linkage' is used inter-changeably with 'data linkage' (Harron, 2016). The subject or content of the record can be an individual person, family, event or place (Winglee et al., 2005). Record linkage usually utilises variables such as name, sex, and date of birth to match records (Winkler, 2005), usually across multiple disparate sources of data (Karmel and Rosman, 2008). Record linkage can also be performed within an individual dataset to measure multiple reoccurrences within the dataset, such as hospital re-admission episodes (Bohensky et al., 2010). In these broad terms, practically all separate records that contain information on or relating to an individual can be brought together to provide information on them (Newcombe et al., 1959).

The term record linkage dates back to the middle of the 20th century when Albert L. Dunn (1946), then Chief of the National Office of Vital Statistics in the United States of America beautifully compared the process of record linkage to the construction of a 'Book of Life'. For every individual, the book starts when they are born, and ends when they die with each page containing key life events. Depending on the individual, the book may just be a single page or two, while for others it may have numerous pages. Dunn eloquently describes that although an individual may recognise the key pages from their own book, for others his/her individual identity needs to be confirmed: 'Is the John Doe who enlists today the same John Doe who was born eighteen years ago?'. Dunn (1946) believed that before the advent of electronic records, it was more often than not the responsibility of the individual to assemble his own book as only they would know the whereabouts of each page or record, particularly when no cross-reference existed across records to allow other individuals or groups to identify all of that persons data. Birth records and other 'facts' recorded in marriage, divorce and death certificates are of importance, but so are records including hospitalisation, military service and social welfare amongst others. Dunn continued his analogy when he recognised the importance of the role of the Registrar in 'binding the Books of Life into volumes'. However, this is where the analogy stopped, and Dunn recognised that it is not the actual physical production of an individual's book that is of most importance, but rather knowing where to find all of the records relating to an individual. Dunn noted that record linkage would lead to: more accurate data due to the identification of discrepancies; improved completeness by identifying missing records; a tackling of fraud; and more significant statistical information. Although Dunn identified the benefits of record linkage for private companies such as Insurance Brokers, he also prophesied the benefits of data linkage to public organisations including health organisations who could ask questions about individuals such as: the number of children they have; vocation; socioeconomic status; and the nature of disease they may have.

An early example of record linkage from around the same period as Dunn's work was the use of 'index punch cards' in Canada (Adams, 1995). Copies of vital records (births, deaths, marriages, etc.) were collected centrally. A unique individual identifier number was punched into a card for each record. Copies of each card were sent to the Province of birth (regardless of where the subsequent record was created) which allowed for the creation of an index file of all of the vital records for an individual. Similarly, a copy of each card would be generated for use in the production of national statistics and data. The individual identifier number was also added to non-vital official records so that these could easily be linked to each person's index file.

Although Dunn was the first person to coin the term 'record linkage' earlier examples of record linkage exist such as Jenner's 18th century study which linked cows to humans in the development of a vaccination for small pox (Machado, 2004). By using linked records as evidence, Jenner was able to demonstrate that he had developed an effective intervention in the prevention of smallpox.

1.8.2 Routine Administrative Data

Routine administrative data are routinely collected by government bodies/authorities and other organisations, primarily for administration and societal functions rather than research and are typically collected for the purpose of general record keeping for services such as education, criminal justice, social welfare, tax, and health (Figlio et al., 2017). Administrative datasets are extremely large datasets and due to their size, the time period they cover, and the wide range of individuals and variables captured in the data, they often provide a cost effective, less intrusive, and more inclusive source of data for research than other sources such as study specific surveys using questionnaires (Garratt et al., 2010).

These large quantities of health records, collected electronically, can therefore be used for the secondary purpose of record linkage to assist in the monitoring and evaluation of health services, as well as for public health research (Kelman et al., 2002).

There has been a growing trend to develop administrative datasets which are more accessible to researchers with censuses being replaced by 'Register' data such as: birth, death, electoral roll, business, building and dwelling, cancer and other health registries (Holman et al., 1999; Wismer, 2003). This is particularly so within Scandinavia with an example being Statistics Denmark who provide linkable register data (Garratt et al., 2010). This has provided benefits to both researchers in Denmark by allowing them controlled access to individual level data to investigate and answer multiple research questions, and to the wider Danish public by lowering public spending by means of re-using data which are already available and reducing the instances of data being requested. For example, Denmark's population and housing census contains data gathered solely from registers, rather than questionnaires completed by the public. This allows for annual releases of up-to-date census results (Wismer, 2003). This is a different approach to the decennial population censuses of the United Kingdom which are based on survey data alone and with a cost reported at £482 million for the 2011 census (Office for National Statistics, 2008).

Another example of administrative datasets are socio-economic status indices such as the area-based deprivation measure, the Scottish Index of Multiple Deprivation (SIMD) that is used in Scotland (Scottish Government, 2016c). Using postcodes, SIMD (and other area-based measures of deprivation) can be linked at the individual level to both routine and study specific data (Barry et al., 2015), providing an area-based indicator of socioeconomic deprivation to the record.

Administrative data can also be linked to study specific survey data to add additional information which would otherwise be unavailable or costly to collect (Lightfoot and Dibben, 2013). A cohort study of babies and their parents in

Bradford, England with high levels of socioeconomic deprivation and infant mortality, and a population consisting of 50% non-white ethnic groups, collected questionnaire and biological data on three occasions; 26-28 weeks into the pregnancy, at birth, and two weeks after the birth. Participants were assigned a unique study specific identification code and a unique patient NHS identification number to allow for the survey data to be linked to a range of administrative data including; demographic data, haematology and biochemistry results, ultrasound data, and general practice data. Information contained within these datasets would otherwise be unavailable or costly for the researchers to collect by other means. Therefore, linking to such administrative datasets allows for a cost effective method of identifying factors that contribute to health problems and the differences in health between differing ethnic groups (Raynor, 2008).

Gowans et al. (2012), from the United Kingdom's Administrative Data Liaison Service, have acknowledged the ongoing growing recognition of the benefits of accessing administrative data for secondary research purposes, although much of this research has focused on health and education, with other types of administrative data such as crime and welfare remaining underused. Jaro (1995) also stated that record linkage has a key role to play in public health research and has most commonly been used for linking morbidity and mortality data as well as linking data for use in longitudinal studies.

1.8.3 Linkage Methods

The idea of using probability to link records was first discussed in 1959 by Newcombe et al. when they were accessing the possibility of a record linkage study that would follow individuals in British Columbia (Canada) who had been exposed to moderate levels of radiation to establish their subsequent fertility and genetic deformities, and the cause of their eventual death. The authors identified problems that may arise from automatically linking pairs of records by computer, due to errors in pairs of records such as inconsistencies in the spelling of surnames (e.g. MacDonald and McDonald), and incorrect ages. Newcombe rightly stated that no individual piece of data can be assumed to be accurate and therefore when linking records, the probability of a correctly matched pair of records should be calculated. Rather than relying on one variable such as surname, a range of variables such as surname, forename and other personal identifiers would be more desirable.

Over the past two decades there has been a marked increase in the number and range of data linkage studies with much of the focus being centred in the USA, UK and Australasia (Silveira and Artmann, 2009; Bohensky et al., 2010). In Scotland alone, there were 150 data linkage studies completed between 2011 and 2014 with researchers from the health, academic and industry sectors utilising what is considered to be some of the highest quality administrative data available anywhere in the world (Pavis and Morris, 2015).

A series of systematic reviews, focused on reporting on the accuracy, success and limitations of data linkage have been undertaken Bohensky et al. (2010) and Silveira and Artmann (2009). Both reported that there is a shortage of literature relating to the completeness and limitations of research that utilises data linkage: Bohensky et al. identified 33 data linkage studies that compared the characteristics of linked records against unlinked records while Silveira and Artmann could only report on six studies that had a full summary measure of linkage quality.

Bohensky et al. (2010) found that a small amount of patient level outcomes such as hospital re-admission rates and mortality rates were readily available from health data sources, but procurement of multiple databases relating to individuals via data linkage was required to cover a wider range of outcomes, confounders, or explanatory factors. Bohensky's review identified two main problems – when two related records cannot be linked due to inadequate data or when the wrong records are incorrectly matched for two unrelated individuals. Bohensky et al. also identified that it would be difficult to measure the quality of data linkage if the outcome variable in a linked dataset is not always available e.g. pregnancy rates for young mothers if it is unknown whether or not the patient is pregnant. This was supported by Silveira and Artmann who stated that additional information is often required to assertion if a pair of linked records are actually true matches. Silveira and Artmann further reported that although the gold standard for linkage studies to ascertain the accuracy of the linkage is for researchers to manually check the links, this is not practical in terms of time and cost, especially in databases that contain vast amounts of records.

It was reported by Bohensky et al. that of the thirty-three data linkage studies that compared the characteristics of linked records against unlinked records, there was an inconsistency in methods used across the studies. The number of patient characteristics utilised for comparison ranged from just one characteristic up to six, and that two differing methodologies were used to measure the accuracy of the linkages. Some studies compared the proportions of the patient characteristics in linked records to unlinked records, while other studies utilised regression analysis to measure the odds of a successful match for each characteristic. Age, gender, ethnicity, socio-economic status and health status were all found to be unevenly distributed between the two groups in the majority of the studies, although for age, gender and ethnicity, the bias often shifted across the groups for these categories e.g. some studies reported males were less likely to be linked while in other studies, it was females. Linkage rates also differed for health status depending on the outcome being compared. However, when comparing linkage rates across socio-economic status, linked records were found to favour patients from more affluent groups. From Bohensky's review, it can be concluded that there is a risk of bias in data linkage with regards to patient characteristics, however, this bias will mostly be dependent on the study, although any potential bias should be reported to allow for an accurate interpretation of the study results.

1.8.3.1 Data Linkage in Scotland

Pavis and Morris (2015) recently reviewed the potential of utilising administrative health data in Scotland or in their words 'unleashing the power of administrative health data'. It was highlighted that while the Community Health Index (CHI) number, a unique patient level identifier that is available for health care records, allows for robust data linkage across health records, utilising probability matching can allow researchers to link health data with cross-sectoral data (such as census and educational databases) that do not contain a CHI number.

Pavis and Morris also provided a detailed overview of the ideologies and methods of data linkage that are applied in Scotland. This includes: the separations of functions between organisations that hold and provide linked data (and also de-identify it) from researchers who link individual level data from multiple datasets from within a secure research portal; the legal basis by which many of these procedures were driven from; and the desire to develop smaller temporary bespoke databases to meet research needs rather than a single super-database that houses all of Scotland's linkable data. Finally, Pavis and Morris highlighted the importance of maintaining and building on the level of trust between data linkage researchers and the general public.

Linkage of medical records in Scotland is long established. This is due to the decision from the Scottish Health Service and the Register General for Scotland that from 1968, all hospital discharge records, cancer registries and morbidity records be held in a central location in a machine readable format and that each record would contain fields that could be used to identify the patient such as: surname; forename; Date of Birth; and place of residence (Walsh et al., 2001). The decision to collect these data was greatly influenced by the aforementioned work by Newcombe (1988).

1.8.4 Data Access and Security

1.8.4.1 Framework for Data Linkage in Scotland

With growing amounts of administrative datasets being stored electronically in Scotland, the Scottish Government has released a series of publications to support data linkage in Scotland.

Initially, a consultation was undertaken as part of the development of a framework for the use of data linkage for research (Scottish Government, 2012a). Overall the responses to the consultation were highly positive although concerns around privacy were raised.

A follow-on document (Scottish Government, 2012d), that set the guiding principles for data linkage usage in Scotland for research stated that: all data linkage projects should be beneficial to the public; transparent governance procedures exist; a balance is required between both privacy and the benefits of research with robust security and anonymisation methods being put in place to ensure the risks of personal data being shared are minimised; all those accessing data should undergo data linkage training; and that appropriate sanctions are applied when there are breaches to the law and the principles of data of linkage in Scotland. The document also outlined the requirements of data controllers, (Scottish Health Informatics Programme, 2012) who are the person or persons who determine the 'purposes for which, and the manner in which, personal data are to be processed'.

1.8.4.2 Safe Havens

A 2008 review (Thomas and Walport, 2008) recommended that ‘Safe Havens’ be established across the United Kingdom to allow population-based research to be undertaken in a secure environment where the risk of disclosing individuals is mitigated.

Traditionally, ‘Safe Havens’ were a physical space such as a secure room where researchers could access potentially identifiable data to undertake data linkage via a standalone computer (Administrative Data Taskforce, 2012). With the development of specialist software, Safe Havens can now be accessed remotely from individuals’ computers although it is not possible for individuals to extract data from the Safe Haven via the software (Scottish Government, 2012a). Safe Havens are accredited by the government where there is ‘a clear legal basis to link data’ (Lee, 2013). Within Scotland, there are currently four regional Safe Havens operating as partnerships between local NHS health boards and academic institutions, and a single National Safe Haven operated by NHS National Services Scotland (Scottish Government, 2015c). These Safe Havens, were developed using the ‘SHIP Blueprint’, a Safe Haven operator in Scotland since 2008, developed as a collaboration between NHS Scotland and four Scottish Universities (Scottish Health Informatics Programme, 2012).

The Scottish Government (2015c) published a charter for the processing, linking and analysis of heath data within a Safe Haven environment for data where it is not practical to obtain individual patient consent. To mitigate the risk of breaches in patient confidentiality: researchers only have access to ‘pseudonymised’ data where identifiable variables such as names and addresses are unavailable; there is a separation of operations concerning data when it is anonymised, linked, and analysed so that datasets cannot be linked and analysed outwith the Safe Haven; and only aggregated data that have been thoroughly checked by Safe Haven support staff for potentially identifiable data (i.e. small numbers) are disclosed from the Safe Haven (Scottish Government, 2014).

1.8.4.3 Information Governance in Scotland

The Privacy Advice Committee (PAC), founded in 1990, was a committee that advised the NHS NSS and The Register General on patient privacy and to ensure appropriate use of health data in Scotland (NHS National Services Scotland, 2015b). This included data used for statistical and public health monitoring and evaluation purposes. The overarching role of the committee was to ensure that a balance was maintained between protecting personal data and approving the release of individual level data that is required for research, audits, and other appropriate uses and that this was done in a controlled manner.

In 2015, PAC along with two other services that were controlled by information governance procedures in Scotland (Scottish Government, 2016b): the Community Health Index Advisory Group (Scottish Government, 2013) which controlled access to the CHI database, and National Caldicott Guardians application (Scottish Government, 2010) were combined into the Public Benefit and Privacy Panel for Health (Public Benefit and Privacy Panel for Health, 2015).

1.8.5 Scottish Safe Haven Studies

One of the earliest examples of Safe Haven usage in Scotland is the Scottish Longitudinal Study which linked data from the national census, birth, death and marriage registries, and NHS datasets. All research was undertaken in secure rooms inside National Records of Scotland premises (Boyle et al., 2008).

The National Safe Haven, which has been operating since 2013, has supported a wide range of data linkage studies. A 2014 study that linked deaths by suicide in Scotland (n = 10,907) via the death register to NHS hospital admission records (n = 69,568) reported data errors, including admission dates that were after the date of death (<1%), as well as duplicate admission records (1%) (Dougall et al., 2014). Records in the study were linked via the CHI number. Dougall et al. noted that researchers working within the Safe Haven environment have a limited capacity to recognise and rectify data errors.

More recently, a retrospective population cohort study was undertaken that linked school census data to multiple education and health datasets to establish a database that could be used to compare a range of educational and health outcomes for school children in Scotland with chronic health conditions in comparison to those children without (Fleming, 2017). The school census was used as the baseline for the assembly of the study cohort. The school census did not contain a CHI number so the census records were probabilistically linked using personal identifiers to the CHI database. Of 3,368,836 children on the school census, 2% of could not be linked to the CHI database. The study also made use of an area-based socioeconomic lookup (SIMD). Overall Fleming's database contained 766,244 unique school children. This database has proved successful in measuring the difference in outcomes in the Scottish population between children receiving antiepileptic medication (Fleming et al., 2019) and children with attention-deficit / hyperactivity disorder (Fleming et al., 2017) with their peers. These combinations of studies emphasise the importance of utilising the tools of the Safe Haven to assemble population level databases that can be used to measure a range of outcomes not exclusive to health.

1.8.5.1 Looked After Children Linkage Methods

A study similar to that which is undertaken in this thesis was conducted by Clark et al. (2017) and is described below in detail. The paper described the methodology of linking routine data collect by social and health services to compare the health outcomes of children in Scotland who were currently (n=10,009) or had previously (n=1,757) been living in state provided care to their peers who were not living in state care at a national level (n=659,186). It was recognised by the Scottish Government (2015a) that the development of methods to facilitate this linkage was urgently required so that health outcomes for looked after children could be measured.

The study initially linked three datasets to establish a robust study cohort: an annual data return from local authorities to the Scottish Government of children living in social care in their authorities; the annual pupil census, a comprehensive record of all children in Scotland attending state funded schools; and the Community Health Index (CHI) database, a database that includes a unique identification number for each NHS patient in Scotland. There was a lack of personal identifiers in the dataset for children living in social care to link this dataset directly to the CHI database, therefore the Scottish Candidate Number (SCN), which was available in both the dataset on children living in social care and the pupil census, was used to deterministically link both of these datasets. The pupil census data, which had a broader collection of identifiers, was probabilistically linked to the CHI database to create a lookup which contained the SCN, whether or not the child was living in social care and the CHI number for each child in the cohort.

The probabilistic linkage used to link CHI to each record in the school census utilised pre-existing algorithms and decision rules created by the NHS Scotland ISD for linking health data (Kendrick et al., 1998). A ‘best match’ method was adopted where the result of the algorithm proposed the best match between the CHI and census record determined by: (i) the accuracy of the match between the identifiable variables in both datasets and, (ii) the closeness of the ‘next best match’ in comparison to the ‘best match’. Based on this, thirteen pre-established match categories were used to consider if the match was ‘safe’ or to be ‘rejected’. Matches that were rejected were not assigned a CHI number.

The proportion of children with safe links was calculated for those children living in social care (94.0%) and those who were not (95.1%), indicating similar linkage results could be obtained for both sets of children. These proportions were further broken down to assess linkage rates between the two groups by age, ethnicity, sex, area deprivation, and local authority of the school. This process identified that for both groups, linkage rates were nominally lower for younger children and those living in more deprived areas.

Linkage rates for those children living in social care were also calculated by the total number of social care placements the child had been homed in, the reason for their placement, and the type of placement, with results indicating that children who had been homed in fewer placements and those who were now residing within a permanent foster home had higher rates of linkage.

The CHI numbers of the linked children were then used for the extraction of and linkage to corresponding health and dental health records held by ISD. This allowed for the analysis and comparison of health outcomes between those children in social care and those who were not. The outcome results of this are published in a separate paper (McMahon et al., 2018). The study was a collaboration between multiple institutions and therefore approvals for this study were required from the Scottish Government Education Analytical Services Division Data Access Panel and the NHS Privacy Advisory Committee.

Overall, Clark and colleagues' study of the methods used to create a linked database described in detail how CHI can be used to link a high proportion of children with no obvious bias towards demographic groups. It is also worth noting from this paper that the school census data did not have surname and forename available, which are important variables normally used in the process of linking to the CHI database, so it would stand to reason that linkage rates would be higher in studies that have access to the full range of personal identifiers.

1.8.6 Childsmile Outcome Evaluation via Data Linkage

To date, much of the monitoring and evaluation analyses for Childsmile has been undertaken via data linkage. This work has been undertaken both outwith a Safe Haven (Kidd, 2012) and within it (Hodgins et al., 2018). NHS National Services Scotland Information Services Division (ISD) have previously provided Childsmile analysts with bespoke datasets that have been utilised in the development of national reports, used for the routine monitoring of the programme (Central Evaluation & Research Team, 2015). However, these bespoke datasets have provided limited opportunity for looking within and across the Childsmile interventions.

A study by Kidd (2012) [thesis author] linked records from a bespoke ISD dataset containing individual child level data relating to Childsmile dental practice appointments to corresponding records that included Health Visitor caries risk assessments, DHSW contacts, and socioeconomic data, to investigate the factors associated with the on-going retention of pre-school children at Childsmile dental practices. The study identified that during the demonstration phase of Childsmile, there remained a level of inequality with regards to those children who regularly attended Childsmile at a dental practice.

Hodgins et al. (2018) utilised the National Safe Haven for a population study to link child level data from datasets relating to Health Visitor contacts, DHSW contacts, and child dental practice attendance. Both the Health Visitor dataset and the dental practice dataset were held by ISD whereas the DHSW dataset was held by the Health Informatics Centre at the University of Dundee. By linking datasets held by multiple agencies within the Safe Haven, it was established that less than half of the children identified by a Health Visitor as requiring support from a DHSW actually received it. However, those that did receive the contact were more likely to attend a dental practice and at a younger age than those who were not contacted by a DHSW. The background linkage methods used in this study are discussed in Section 2.3 of this thesis.

It can be summarised from these studies that data linkage has thus far been an effective method of measuring outcomes of the Childsmile programme. The Safe Haven provides the infrastructure and potential to securely link multiple datasets from multiple data controllers that would otherwise have not been possible. Thus far, however, the data linkage work has only analysed the delivery of the programme and not evaluated any health outcomes.

1.9 Summary of debates and gaps in the literature

Dental caries is the most common non-communicable disease worldwide (Vos et al., 2017). Dental caries can severely impact on an individual's quality of life with childhood caries being a marker for continued caries prevalence as well as poor general health throughout life (Macpherson et al., 2019a). The prevalence of child caries is unequally distributed across the population with children living in the poorest areas bearing the greatest burden of the disease (Conway et al., 2014).

According to epidemiological surveys at the beginning of the century, children in Scotland traditionally had the worst oral health in the United Kingdom and among the worst in Europe (Scottish Dental Epidemiological Co-ordinating Committee, 2003). The improvement of child oral health in Scotland was and is seen as a priority for the Scottish Government (Scottish Executive, 2002). Building on World Health Organisation guidelines, and general health service development, there has begun a shift towards preventive methods rather than treatment in the combat of diseases (World Health Organisation, 1986). Biological risk factors of caries (and other chronic diseases) had been the dominant aetiological model, but this has changed over recent decades, with more focus on social determinants (Watt, 2012; Macpherson et al., 2019a).

There has been mixed success of early oral health interventions in practice and in the community, and great care is required to ensure that there is no inverse impact widening oral health inequalities. It has been shown that oral health education interventions are particularly vulnerable to this (Schou and Wight, 1994). In a report to the Scottish Government Taskforce on Health Inequalities, Dame Professor Sally Macintyre singles out this case, but the report goes further to describe the principles of policies that are effective alongside those that are ineffective in reducing health inequalities (Macintyre, 2007).

There is also an abundance of evidence to support toothbrushing with at least 1000 ppm fluoride toothpaste as an effective measure in reducing the risk of dental caries (Marinho et al., 2003). There has been much debate in recent years about the effectiveness of fluoride varnish, but there is limited evaluation of its use as part of public health programmes.

Community based interventions that are tailored towards the community they are being delivered within are effective at reducing the risk of caries (Blair et al., 2006) although combinations of chairside, community-based, and policy based interventions may be the most effective methods of reducing the risk of caries (Macpherson et al., 2019a) i.e. interventions operating at all levels: downstream clinical, midstream community, as well as upstream policy levels (Watt, 2012).

Childsmile was developed to improve child oral health in Scotland and reduce inequalities with regards to both oral health and accessing dental services (Macpherson et al., 2010a). Using a combination of theory and evidence, Childsmile has delivered oral health promotion including daily supervised toothbrushing universally to nursery children across the country (Anopa et al., 2015). It has also supported the reorientation of dental services towards delivering preventive interventions to children from a young age (Wright et al., 2015). This included the introduction of the Childsmile preventive items into mainstream dentistry (Scottish Government, 2011b) as well as other upstream approaches such as changes in policy related to healthy eating in educational settings (Scottish Government, 2008). Childsmile has also established itself within local communities, not just in terms of dental health but within non-dental groups and agencies (Macpherson et al., 2019b) and targeted fluoride varnish applications are also delivered in nurseries and schools that are located in areas of high deprivation (Wright et al., 2015).

A direct impact between the roll-out of the Childsmile supervised toothbrushing intervention and the reduction in obvious caries experience in five-year-old children in Scotland has been observed. The effect was most predominant for children living in the areas of highest deprivation (Macpherson et al., 2013a). However, it did not measure the relationship between total time exposure of the intervention for individual children and improvements in oral health. It is a logical follow-on to this that the variation of this exposure experience has also not been measured between children from different socioeconomic backgrounds.

Although there is evidence to support the role of the DHSW in facilitating a child with a dental appointment earlier than those not reached (Hodgins et al., 2018), the role of the DHSW in supporting any reductions in obvious caries experience remains unknown. Moreover, there has so far been no analysis of the effect of Childsmile dental practice contacts or of the variation of the interventions that are delivered within this component of the programme on caries.

Oral health programmes need to be monitored and evaluated regularly and if they are not working as intended, they should be modified (Petersen and Kwan, 2004). It therefore essential and expected that a full outcome analysis of the Childsmile programme is undertaken. This is firstly required to ensure that the programme is being delivered as intended i.e. that the targeted elements of the programme are reaching those at greatest need from the most deprived communities, and secondly, that the universal components are reaching all groups in the population (without an inverse uptake among the least deprived). The second requirement is to understand the role of each Childsmile component in reducing the risk of dental caries and how this varies by level / duration of exposure and by deprivation status. It is also important to understand how each of the Childsmile components / interventions are interacting with each other and if there are synergies or antagonisms between the various components of Childsmile interventions.

Childsmile is a unique programme in that it is now a long-established complex public health intervention that has been incorporated into mainstream Scottish health care and policies. There is no gold standard method for analysing a complex intervention such as Childsmile (Minary et al., 2019), but theory of change approaches as discussed earlier, based on the logic model, seem most appropriate. From a health outcome prospective, one methodology that would seem appropriate is a cohort study of children born into the programme. A retrospective cohort study of the five-year old population with a similar start and end date where each member of the cohort had in theory the same level of opportunity to participate in Childsmile seems the most appropriate approach to undertaking this study when there was no random or staggered roll-out that would permit a more experimental design. The approach is largely data driven – utilising routine administrative data rather than primary collection. Population level dental caries data are available for five- and 11-year-olds in Scotland (Macpherson et al., 2014). Although this data is available for research purposes, thus far, the research has been limited to analysing aggregated data rather than at the individual child level (Blair et al., 2013; Macpherson et al., 2013a).

Data linkage allows a unique opportunity to undertake an outcome analysis of Childsmile at a population level. Safe Havens are excellent tools that provide a secure environment that promotes research and by identifying and linking appropriate datasets, the data can be used to analyse a whole series of outcomes rather than just a single outcome (Fleming et al., 2012) thus rendering it an efficient and effective use of resources. At the onset of this thesis in 2012, the use of Safe Havens in Scotland, particularly the newly established National Safe Haven was in its infancy (Scottish Health Informatics Programme, 2012) and initial studies would be required to pilot the software to ensure that this research platform would meet the requirements of researchers who required multiple linked and anonymised sets of ‘Big Data’.

1.10 Aims, Objectives and Research Questions

1.10.1 Overarching Aims and Research Questions

The overarching aim of this thesis is to assess the impact of the measurable input at individual child level of the Childsmile programme on the oral health outcome of obvious dental caries experience of five-year-olds, taking into account socioeconomic deprivation. This aim will be met via answering the following research questions.

1. Is the Childsmile programme and its universal and targeted components being delivered as envisaged and does this differ by socioeconomic status of the child population?

2. What is the association between obvious dental caries experience and sociodemographic characteristics (age, sex, and area-based deprivation) of a five-year-old study cohort?

3. What is the impact of each of the individual components of the Childsmile programme on obvious dental caries experience, and is there variation of the impact by sociodemographic characteristics?

4. What is the independent effect of each of the Childsmile components over and above the other interventions and the relative contributions of each of the components of Childsmile on obvious caries experience within both the whole child population and for children living in the areas of highest deprivation?

These questions will be primarily addressed in the analysis in Chapter Four. Chapters two and three set out a number of methodological aims and objectives with the overarching purpose of obtaining and linking the population-national-data that is required to answer the above research questions.

1.10.2 Chapter Two Aims and Objectives

The aim of chapter two is to establish a series of linked and anonymised child level source datasets from multiple sources via a process of data management, quality and completeness checks.

The objectives of Chapter Two are to:

1. Gain ethical and Information Governance approval to access and link multiple individual child level datasets within a Safe Haven environment.

2. Identify and specify the datasets and variables that are relevant to the larger Childsmile evaluation (in addition to the initial analyses planned for this thesis) as part of the development of a research infrastructure within the Safe Haven for future research.

3. Extract and process the University of Glasgow Community Oral Health Department’s (COH) held Childsmile datasets as anonymised but linkable datasets for inclusion in the National Safe Haven.

4. Pilot the NHS Scotland data linkage infrastructure system.

5. Undertake quality and completeness assessments of the datasets that were uploaded into the Safe Haven.

6. Create a birth cohort with child oral health outcomes to be used for the main evaluation of the Childsmile programme.

1.10.3 Chapter Three Aims and Objectives

The aim of Chapter 3 was to create and describe a cohort that would enable the initial outcome evaluation analysis of the Childsmile programme.

The objectives of this second methods chapter are to:

1. Assemble and describe a series of linked multiple datasets to assess their potential for evaluating the effectiveness of the Childsmile Programme.

2. Create the outcome variable (obvious dental caries experience of 5-year-olds) – derived from a routine administrative dataset, which can be used as the primary oral health outcome for the evaluation of Childsmile.

3. Undertake data management of the source datasets (Childsmile component datasets and outcome dataset) so that they can be linked to establish a study birth cohort to analyse the impact of the whole Childsmile programme and its components.

Chapter 2 – Methods: Childsmile Source Dataset Indexing, Management and Quality Checks

2.1 Chapter 2 Introduction

This chapter details the processes of establishing a series of linked and anonymised source databases in a remote Safe Haven environment via a process of data management, and quality and completeness checks. The overarching aim was to create a cohort that would enable the evaluation of the effectiveness of the Childsmile programme in relation to child oral health and inequalities in child oral health using data at the individual child level. The Childsmile programme includes: supervised toothbrushing in nursery and school; fluoride varnish applications in nursery and school; community-based Dental Health Support Worker (DHSW) contacts; and Childsmile dental practice-based interventions. Analysis of this cohort will enable the evaluation of the impact on child oral health of these components of Childsmile both individually and in combination.

This chapter is split into two distinct chronological sections: 'Phase One' and 'Phase Two'.

Phase One concerns: i) the initial ethical and information governance approval processes for accessing and linking the source datasets to be used in the study; ii) identification of the appropriate source datasets that were to be used in the outcome evaluation of the Childsmile programme; iii) installation and pilot use of the National Health Service (NHS) National Service Scotland (NSS) electronic Data Research and Innovation Service (eDRIS) remote National Safe Haven infrastructure software; and iv) extraction and uploading of datasets (including the initial linkage process) into the Safe Haven; and v) the subsequent primary analysis of these datasets.

It was envisaged at the onset of this study that there would be an initial comprehensive analysis of the linked data undertaken in Phase One which would then be updated with more recent data after two years in Phase Two. However, due to substantial data quality issues identified during Phase One, which is discussed in detail in this chapter, it was not possible to undertake a comprehensive analysis of the Childsmile programme at that stage. Thus, Phase

One is considered a pilot phase, and indeed was one of the national pilot projects providing one of the first opportunities for the infrastructure of the National Safe Haven secure remote data linkage service to be tested. The processes and learning not only informed the Childsmile evaluation, but also the wider data linkage methods and systems in NHS Scotland.

Phase Two consists of: i) gaining updated consent to access and link multiple individual child level datasets to progress with the outcome analysis of Childsmile; ii) using updated data linkage processes for the sharing and uploading of the refreshed source datasets into the Safe Haven; iii) further primary analysis of the datasets to measure and validate data quality and completeness; and iv) initial primary analysis of the datasets to validate the linkage process.

The main aim of this chapter is to describe the establishment of a series of linked and anonymised child level source databases from many sources via a process of data management, quality and completeness checks. These linked datasets will then be used to establish a study cohort to evaluate the complex multifaceted components within the Childsmile programme.

2.2 Chapter 2 Objectives

The objectives of this chapter were to:

1. Gain ethical and Information Governance approval to access and link multiple individual child level datasets within the NHS NSS Remote Safe Haven.

2. Identify and specify the datasets and variables available to be used in the data linkage study datasets (as well as other datasets that are relevant to the larger Childsmile evaluation as part of the development of a research structure within the Safe Haven for potential future Childsmile outcome analyses).

3. Extract and process the University of Glasgow Community Oral Health Department’s (COH) held Childsmile datasets as anonymised but linkable datasets for inclusion in the study.

4. Pilot the NHS Scotland data linkage infrastructure system including the remote Safe Haven and analysis software both generally and in relation to the Childsmile datasets.

5. Undertake quality and completeness assessments of the datasets that were uploaded into the Safe Haven.

6. Create a birth cohort with child oral health outcomes to be used for the main evaluation of the Childsmile programme.

2.3 Phase One Methods

This section describes:

i) Methods of gaining approval to access and link multiple individual child level datasets to complete an outcome analysis (as well as other datasets that are relevant to the larger Childsmile evaluation).

ii) Identification of appropriate source datasets that could be used to complete this task.

iii) Trialling the installation and use of the data analysis and linkage software contained within the data linkage infrastructure.

iv) Initial linkage process undertaken on the source datasets prior to being uploaded into the Safe Haven.

v) Sharing and uploading of datasets into the Safe Haven.

vi) Validation of the linkage process.

The time-period for Phase One was from early 2008 to March 2015.

2.3.1 Community Oral Health Section Confidential Data Security Protocol

The *Community Oral Health Section Confidential Data Security Protocol* is a document that sets out the procedures within the COH section of the University of Glasgow for the handling and processing of confidential data.

This document covers:

i. Recording / entering of data including data accuracy and validation.

ii. The restricted use of mobile devices; data should not be stored on portable storage devices such as key sticks, CDs, external hard-drives or smart phones.

iii. Storage of password controlled electronic data in the University of Glasgow's secure server with access to the data on a 'need to use' basis.

iv. Transfer of data from and to COH via secure NHS email or an NHS Scotland approved Secure File Transfer Protocol provider.

The data security protocol was in part developed to enable the COH research group to undertake monitoring and evaluation of the Childsmile programme as well as to enable Information Governance approvals to be gained.

2.3.2 Information Governance Approval – Phase One

In early 2008, the Childsmile Evaluation Board proposed to undertake a data linkage study to evaluate the effectiveness of the Childsmile programme on child health outcomes. An application form entitled *Application to Use Individual Records for Medical Research or Audit* was completed and submitted to the Privacy Advisory Committee (PAC) of NHS National Services Scotland Information Services Division (ISD) in September 2008. This was the information governance committee for NHS Scotland at this time.

Alongside a request for approval, the application included: a description of the study and its aims and objectives, an indication that the study involved individual child data linkage between routine administrative NHS datasets held both in ISD and datasets external to ISD (i.e. the Childsmile intervention datasets held at both the University of Glasgow and the University of Dundee). At this early stage in the study, the application indicated that the study involved linking datasets containing data relevant to the Childsmile programme held by three different organisations (data-controllers):

1. University of Glasgow Dental School COH for Dental Health Support Worker (DHSW) contacts and Childsmile dental practice intervention datasets collected during the demonstration phase of the programme.

2. University of Dundee's Health Informatics Centre (HIC) for Childsmile Nursery and School intervention datasets.

3. NSS ISD which holds, collates and analyses health service data and statistics and provides information services for NHS Scotland, held the:

- Management Information and Dental Accounting System (MIDAS) dataset which is the primary care dental NHS database with data on patient dental registrations and dental treatments provided by NHS primary care dentists in Scotland.

- National Dental Inspection Programme dataset includes data on individual child oral health, dental caries levels and need for dental treatment of Primary 1 (P1) children (aged 5 to 6 years old) and Primary 7 (P7) children (aged 11 to 12 years old) attending local authority schools.

- General / Acute Inpatient and Day case – Scottish Morbidity Record (SMR01) dataset, including data on day case and hospital admissions for dental extraction procedures under general anaesthetic.

- Child Health Systems Programme – School (CHSP-S) dataset including general health indicators such as height and weight which can be used to calculate body mass index (BMI).

Full detailed descriptions, including data dictionaries of all the datasets used in this study are provided in Section 2.3.9. At this early stage in the evaluation of Childsmile, it was envisaged that the datasets would be held and analysed within a secure drive at the University of Glasgow (as there was no such thing as the National Safe Haven) – hence the need for the development of a data security protocol. It was also thought that this approval (while early) would cover the duration of the Childsmile evaluation and would permit a pilot analysis before the cohort would mature over the coming years. The application was approved by PAC in January 2009 (Appendix 1) and was valid for five years from the date of approval.

2.3.3 Ethical Approval – Phase One

At the time of submission of the initial application to PAC in 2009, no formal ethical approval from the University of Glasgow had been required due to the overall Childsmile evaluation project being decreed as a service development and evaluation by the NHS Research Ethics Committee Scientific Officer. Thus, NHS ethics approval was not requested. However, because the evaluation was being led by the research team at COH, University of Glasgow ethics committee approval was requested.

An application entitled *Evaluation and development of Childsmile – the national oral health demonstration programme for Scotland* was submitted to the University of Glasgow Faculty of Medicine Research Ethics Committee in June 2009 with ethical approval being granted in December 2009 (Appendix 2). This was an all-encompassing application that detailed the multiple branches of the evaluation. This particular research project was included within the ethics application and therefore was approved as part of the overall ethical approval for the evaluation of Childsmile. An extension to this ethical approval was granted in May 2013 (Appendix 3).

These approvals allowed for the linkage of Childsmile datasets to be undertaken locally at COH which were subsequently used in the production of annual Childsmile Headline Reports (Central Evaluation & Research Team, 2011) and for student research projects e.g. Kidd (2012).

2.3.4 NHS National Services Scotland National Safe Haven

In the time between 2009 and 2012, and with growing amounts of administrative datasets being stored electronically, after consultation both with public health and health service researchers in Scotland, the Scottish Government published a series of publications on their data linkage strategies. These strategies were designed to develop 'a culture where legal, ethical and secure data linkage is accepted, to minimise risk to privacy, and to facilitate the full realisation of the benefits of data linkage' (Scottish Government, 2012d) and the use of Safe Havens to link administrative datasets was proposed as the best method for carrying these strategies out.

In November 2012, NHS NSS National Safe Haven was launched to provide researchers intending to use NHS Scotland data a safe and secure platform from which they could access, link and analyse both NHS data and a wide range of other administrative and research datasets. As this study would be analysing multiple datasets to evaluate Childsmile outcomes, rather than storing and analysing the data to be used in the study within the University of Glasgow's secure drive as previously anticipated (Section 2.3.2), this work was now required to be completed within the National Safe Haven.

2.3.4.1 electronic Data Research and Innovation Service (eDRIS)

The first step in the process of accessing the National Safe Haven was to contact the electronic Data Research and Innovation Service (eDRIS). eDRIS was developed as a service to support national data linkage work. It was hosted within NHS NSS ISD and it provided a named Research Coordinator to support access to the Safe Haven. The Research Coordinator provided guidance and support for understanding the process required to link electronic patient records (EPRs). This included advice on the suitability of the NHS datasets, in gaining appropriate consent to access and link the datasets required for the study and supported the Childsmile team in achieving ‘approved researcher’ and ‘eDRIS user’ status which is a pre-requirement for each individual researcher accessing data in the Safe Haven or involved in the project. Specific advice was also provided on accessing the Safe Haven including software installation and logon credentials. eDRIS also would review and ‘disclose’ any outputs that were requested by the researcher prior to the output being released from the Safe Haven to ensure that no identifiable or confidential data were extracted at any stage of the process.

2.3.4.2 Approved Researcher and eDRIS User Status

All persons wishing to access and use the Safe Haven had to achieve eDRIS ‘approved researcher’ status. This involved completing an approved Information Governance course which contained guidance on the governance of individual privacy, data protection and freedom of information. Being an approved researcher was also the first of five criteria required to be granted ‘eDRIS user’ status, that is, someone who can access the Safe Haven and the data within it for a specific study. The other four criteria were: to be named in the study’s approved application to PAC; to be affiliated with an ‘approved organisation’ (of which University of Glasgow is); to have read the NHS Confidentiality Code of Practice; and to have read and signed the eDRIS ‘Users Agreement’. In December 2012, the author attended the Administrative Data Liaison Service Safe Researcher training course, a course that was designed to help researchers to develop their skills and knowledge to use administrative data resources in a responsible and secure manner. Upon completion of this course, the organisers of the training course granted approved researcher status (valid until 18th December 2014). This enabled access to NHS Scotland health administrative datasets and Scottish Government Linked Social Care, Housing and Health datasets. At this point, no formal certification for completion of the course was available and instead, the names of those who had completed the approved courses were supplied to eDRIS.

2.3.4.3 Safe Haven Pilot (Installation and Access to Remote Desktop)

The National Safe Haven is a secure research portal that was provided by the Information Technology company AtoS from its launch in November 2012 until November 2015 on behalf of NSS. The Safe Haven could be accessed either: a) within a physical secure access area in NHS buildings with workstations provided exclusively for working with data that are held within the Safe Haven; or b) via a remotely accessed portal which provided approved users access to the National Safe Haven environment using a local computer outside of the physical secure access area. As the only physical secure access area at that point in time was in Edinburgh, coupled with the envisaged complexity and timeframe of the study, it was decided the best method or accessing the National Safe Haven for this study was via the remotely accessed portal. However, at this time, the remote access infrastructure had not been fully tested. Choosing this method also provided an opportunity for this study to be part of the national pilot testing the remote access software and environment on behalf of the eDRIS team. This included the installation of and access to the remote portal on a local University of Glasgow computer and the use of analysis and software packages contained within the portal.

A computer in the University of Glasgow COH was linked to the National Safe Haven via a virtual private network (VPN) by following instructions within an installation guide provided by eDRIS. To connect to the National Safe Haven via a VPN, a virtual ‘soft token’ code was first required. The ‘soft token’ was available as a smartphone application provided by ‘RSA’ SecurID. The smartphone application could be downloaded onto smartphones with either Android or Apple software via the smartphone’s ‘app store’. To activate the application, users entered their username and pin number which were supplied by AtoS. After completing the installation of the RSA ‘soft token’ application, users could enter their pin number into the soft token which would generate a one-time passcode (OTP) valid for a maximum of sixty seconds. To install the VPN, users were required to register with the NHS Scotland Connect VPN Service via a VPN gateway webpage by entering their username and an OTP generated by the RSA token into the webpage. This allowed users to download the Cisco AnyConnect Secure Mobility Client VPN (Client VPN) software onto their local computer. This software was used to authenticate users when connecting to the NHS Scotland VPN. The next stage in the process was to install Citrix Receiver software. This software allowed users to link their local computer to a virtual desktop. In this instance, the virtual desktop would be the same desktop the user would have accessed had they logged onto a workstation within the National Safe Haven's physical secure access area.

After the installation of the Client VPN software and the Citrix Receiver, each time the user wished to connect to the Citrix environment and the virtual desktop, they would first have to connect to the NHS Scotland VPN by opening the Client VPN software on their computer and then enter their username and an OTP generated by the RSA soft token. It should then have been possible to visit the secure https URL address (only accessible once connected to the NHS Scotland VPN), enter a username and password which would have launched the Citrix Receiver Software, in turn providing access to an online portal environment giving the user access to their virtual desktop. During the piloting of the procedures of remote access, several issues were encountered:

i. University of Glasgow computers would only connect to the secure https URL address when using Windows XP operating service (University of Glasgow computers used Windows 7, a more recent operating service with the University of Glasgow no longer providing IT support for Windows XP users). This was discovered when testing the software on a University of Glasgow computer which had not yet been upgraded to Windows 7.

ii. It was also identified via the University of Glasgow computer using Windows XP, that University of Glasgow computers would only connect to the secure URL when using Google Chrome browser (as opposed to system default Internet Explorer).

iii. Once connected to the remote platform, it was discovered that the wrong study directory (i.e. the files and folders specific to the study) had been assigned to this project and therefore no datasets were available at this stage for the researchers to analyse.

iv. Users of the remote Safe Haven were enforced to change their password on a very regular basis (monthly), however, it was not possible for users to do this (users were prompted to contact an administrator (i.e. eDRIS) to have their password changed. Additionally, no guidance had been provided within the installation guide on how to change the password.

These issues were reported to the eDRIS Co-ordinator. Working alongside AtoS IT support to troubleshoot issues i) and ii), it was discovered that access to the secure URL via Windows 7 and any internet browser could be achieved by turning off the ‘automatic configuration script’ within the Local Area Network settings section of the University of Glasgow computer’s Internet Options. During the time period where issues i) and ii) were being resolved, eDRIS were able to assign the correct study directory, thus providing access to the datasets required for this study. Users were also given administration rights to update their passwords by eDRIS who also updated their installation guide to reflect the resolution to issues i), ii) and iv).

2.3.4.4 Safe Haven Pilot (SAS Enterprise)

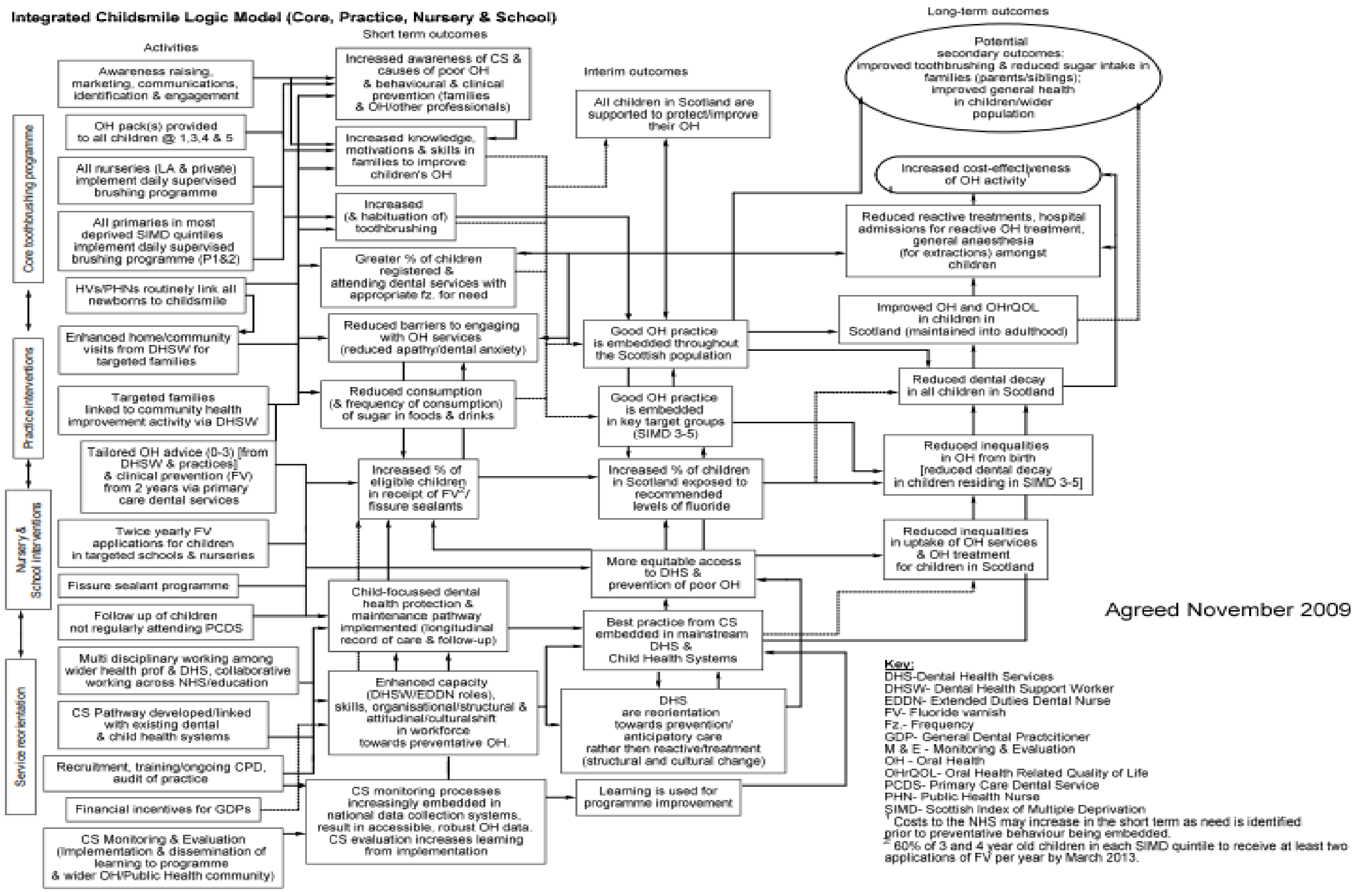
The virtual desktop contained multiple analysis software packages (R, SPSS, STATA and SAS Enterprise). Statistical Analysis Software (SAS) Enterprise was chosen as the analysis software to be used in this study, therefore the next stage was to do a pilot test on this software to test if it worked within the Safe Haven. When testing the SAS Enterprise software, several issues were identified. Data could not be imported manually into SAS Enterprise using syntax although it was possible to import data using the ‘import wizard’. Some of the datasets being imported were extremely large (e.g. 1.6GB) and using the import wizard resulted in SAS indicating that the file had to be manually read in. Datasets could not be exported out of SAS Enterprise and into the study directory as SAS files (.sas7dbat) although it was possible to do so as a Microsoft Excel or text file. It was not possible to create an ‘.rtf file’ via ‘ODS Output’ (this option was planned to be used when writing syntax to generate and export publication ready tables and graphs from SAS into Microsoft Word readable files). When viewing a SAS dataset, it was also not possible to ’send’ the dataset to Microsoft Word although it was possible to ‘send’ it to Microsoft Excel. An error message indicated that SAS had not been enabled for sending reports to Microsoft Word. All of these issues, that were discovered during the analysis piloting of the version of SAS Enterprise software housed within the Safe Haven, were reported to eDRIS, who investigated and consequently resolved them. This allowed both the research in this thesis and subsequent users of the National Safe Haven to access a fully functioning version of SAS Enterprise.

2.3.5 Dataset Scoping

An initial scoping exercise was undertaken to identify the potential source datasets, variables and the data providers to be used in the study. This was based on the Childsmile Programme and Evaluation Logic Model (Figure 2-1).

Representatives of the data providers were invited to discuss the completeness and availability of their data. From these discussions, the dataset that would provide the primary Childsmile outcome measure was identified (NDIP) and the dataset that would form the baseline for the birth cohort was selected along with the relevant variables (Child Health Systems Programme Pre-School 6-8 Week Review). The other source datasets to be linked to the baseline and outcome datasets, which provided information on interventions and intermediate outcomes, were also identified. The relevant date range for each dataset were specified along with inclusion/exclusion criteria (i.e. only records where there was a corresponding record in a baseline dataset would be included rather obtaining every record in each of the datasets to avoid accessing child records that were not relevant to the study). The need for full date of birth, a potentially identifiable variable was also identified.

Figure 2-1: Childsmile Logic Model



Extract from the Childsmile Logic Model (Childsmile, 2010)

2.3.6 Amendments to Information Governance Approvals

The data scoping exercise identified amendments that would have to be made to the previously approved PAC application. These amendments included: accessing and linking the data in the Safe Haven rather than at the University of Glasgow; specifying the names of the data users that would be accessing the data; the inclusion of an additional dataset (i.e. Child Health Systems Programme Pre-School 6-8 Week Review); and requirement for full date of birth.

After discussion with the NHS NSS ISD Caldicott Guardian in December 2012, it was confirmed that a resubmission of the PAC application was not required as they did not need to reconsider the data protection / sharing issues related to the linkage proposals as they had already considered the principles of linking data for the Childsmile data linkage study. Instead a cover letter to the NHS NSS ISD Caldicott Guardian was submitted detailing the amendments to the original application. These included an explanation as to why the additional datasets and fields being requested as part of the amendment were not included on the original application and why they were now required. This letter to the Caldicott Guardian also included the names of the data users and details of their approved researcher status plus additional and detailed information on the specification of the planned linkage work (including details of the variable fields that were to be included within the datasets). To support this letter to the Caldicott Guardian, a document listing each dataset, the fields required from each dataset (including a description of the field), and the date range for each variable was included. The explanation for the requirement of the Child Health Systems Programme Pre-School 6-8 Week Review (CHS 6-8WR) dataset was that this dataset provided the best denominator for establishing a ‘birth’ cohort to assess the ‘dose’ of Childsmile intervention (i.e. the nature and amount of Childsmile interventions received since birth) received across the early years. It was also noted that since the original application had been submitted, there had been changes to the variable fields that were collected within the CHS 6-8WR dataset which included the fields that specifically related to referral to Childsmile (Section 2.3.9.1). It was also noted that there was now full clarity on the range of the variables that were currently available from the Childsmile HIC intervention database. At the time of submission of the original application, the full range of variables held by HIC was unknown due to ongoing modifications in their data collection system.

The letter to the ISD Caldicott Guardian was submitted in March 2013 (Appendix 4).

The ISD Caldicott Guardian then replied, requesting a detailed explanation as to why potentially identifiable variables (which may lead to increased risk of identifying individuals) were necessary. Specifically, these variables were:

- Complete date of birth (dd, mm, yyyy).
- Complete date (dd, mm, yyyy) of: assessments; treatments; registrations; interventions.
- Full postcodes of: child's home; dental practice; school, DHSW base.

These variables, in their relevant format, were specific to every child level dataset that was requested for use in this study. Although an alternative option to full dates was to provide just the month and year, the argument that was provided against choosing this was because the exact date of birth was required to calculate the age of the child at each intervention accurately. For the purposes of the evaluation, the exact age was to be calculated at a number of time points relating to interventions and outcomes throughout the early life course of the children which covers a short period of time (pre-school). Many disease outcomes were significantly associated with age and particularly in young children, small differences in age are important when measuring exposure time. Age was also considered a major confounder in many exposure-disease associations and again, a fine grading of age was required. When analysing studies in small children, even a month would be a large proportion of a child's exposure time. For example, even a week out of six months exposure is 4% of the total time, or 8% out of three months exposure. If the day, month and year were not provided, this would introduce a wide margin of error in the analysis and could compound further inaccuracies down the line. Additionally, children may have received a high number of interventions from providers and sources in a short space of time, full dates were required to sort events in chronological date order when analysing the data.

It was agreed with the Caldicott Guardian that postcodes would be removed and replaced with higher level geographical and area-based socio-economic variables, although the inclusion of geographical levels lower than the high-level health board (HB) were further queried by the Caldicott Guardian. As Childsmile was set-up and rolled out on a Community Health Partnership basis (geographical level smaller than HB), the delivery of the programme was known to vary at the local level, it was agreed with the Caldicott Guardian that these were essential variables and would therefore be provided for this study.

Final approval for all of the datasets and the variables contained within them required for the study was granted by the ISD Caldicott Guardian on 1st October 2013 via an email to the eDRIS study coordinator, although no formal letter or documentation was issued for this.

2.3.7 Community Health Index (CHI) Number

The Community Health Index (CHI) is an NHS Scotland population database that provides a unique ten-digit identification number to each person living in Scotland. This is assigned to a person when they initially register with an NHS health service (ISD Scotland, 2019c). The first six numbers of the CHI number contain the individuals date of birth and the ninth digit indicates their sex. Therefore, it is in effect an identifiable data field rather than a pseudorandomised ID - hence it is used in processing and linking of data, but then removed after the linkage is complete and the researchers do not get to see the CHI number.

CHI was used in each dataset contained in this study. At the point of data collection, the CHI number was either already pre-populated on the form or was added later by means of probability matching (Table 2-1). Probability matching methods linked the child's name, sex, date of birth and postcode to the corresponding variables with the CHI database (Bhopal et al., 2010). This method of probability matching is a universally accepted method but it is not always accurate and errors can occur (Fleming, 2017). Previous work undertaken to validate the linkage of CHI numbers to child records in education datasets indicated that 99% of children were matched to the correct CHI number (Wood et al., 2013; Clark, 2015).

Table 2-1: Method of CHI assignment to Datasets

Dataset	CHI Assignment
P1 Basic NDIP	Probability
SMR01	Pre-populated
Child Health Systems Programme – School Primary One Screening	Pre-populated
CHS 6-8WR	Pre-populated
HVCRA	Pre-populated
Record of Child / Parent Contact	Pre-populated
DHSW Courtesy Visit	Pre-populated
HIC DHSW Practice Interventions	Pre-populated
Toothbrushing Consent	Probability
Fluoride Varnish Dataset	Probability
Invitation to Childsmile	Pre-populated
MIDAS	Probability
Childsmile Dental Practice	Probability / Pre-populated

NIDP datasets are one of the few datasets in ISD that does not have CHI routinely collected. The process of attaching CHI numbers to datasets is called chi-seeding. Scoring points are assigned as follows: Forename eight to seventeen points; Surname eight to seventeen points; Date of Birth up to 15 points; Sex 1 point or minus 6 points; and postcode up to 15 points. If there is no exact match between the identifiers, then probability is used to calculate the odds of the records belonging to same person. ‘These odds are converted into a binit weight which is the odds ratio expressed as a logarithm to base 2’ (Kendrick and Clarke, 1993). The higher the weight the better the chance that the records belong to the same person although regardless of how high the weight is, there remains no guarantee that the two records are for the same person. Cumulative data provided by ISD stated that by 2015, 6% of all records in the MIDAS database (child and adult) could not be linked to CHI (although the percentage without CHI only increased by 0.1% to 0.3% each year). ISD provided data also reported that <1% of records in the Basic NDIP could not be assigned a CHI. A sample of CHI linkage rates provided by HIC reported that around 99% of Primary One child records in the fluoride varnish dataset had been linked to the CHI database in the 2014/2015 school year.

2.3.8 Scottish Index of Multiple Deprivation

The Scottish Index of Multiple Deprivation (SIMD) is an area level measure of deprivation in Scotland (Scottish Government, 2016c). At the point of application, four SIMDs were in publication: 2004, 2006, 2009 version 2 and 2012. The population of Scotland is split evenly into circa 6500-7000 data zones, depending on the SIMD publication observed. Data zones tend to make use of natural boundaries and contain households with comparable social characteristics (Scottish Government, 2011a). There are 38 indicators of deprivation such as access to health services, health and crime rates. These indicators are grouped into seven weighted domains:

- Income (7 indicators, 28% of the total weighting).
- Employment (3 indicators, 28% of the total weighting),
- Health (7 indicators, 14% of the total weighting),
- Education, skills and training (5 indicators, 14% of the total weighting),
- Geographic Access to Services (8 indicators, 9% of the total weighting),
- Crime (6 indicators, 5% of the total weighting)
- Housing (2 indicators, 2% of the total weighting)

The weight of each domain is used to calculate the overall deprivation score for each domain (Fischbacher, 2014). The individual data zones are then ranked by order of deprivation. This ranking is then chunked into tenths (deciles) or fifths (quintiles) with ‘1’ being the most deprived and ‘10’ or ‘5’ being the least deprived. The variables that are available in the SIMD publications include overall data zone ranking (national and locally by health board), domain ranking, urban/rural classification of data zones and geographical location such as health board and council area of the data zone. Routine administrative data can be linked to SIMD via postcode. All of the aforementioned datasets had all four versions of SIMD appended onto the dataset. The method of selecting a SIMD version for analysis purposes in discussed in Section 2.6.4.1.

2.3.9 Description of Datasets – Phase One

The following section describes the datasets (Figures 2-2 and 2-3) that were identified for both inclusion in this study as well as those identified for the wider Childsmile evaluation.

This includes information on: the primary function of the dataset, the history of the dataset, who the data controller was, any knowledge relating to the completeness known prior to the data extraction, and inclusion criteria if only a subsample of the dataset was to be used. Information on datasets that have been excluded from the study are also included.

All of the datasets are at an individual child level and had collected the child's forename, surname, gender, home postcode (although these were removed prior to the data being supplied into the Safe Haven) and date of birth as standard. All the datasets with the exemption of the NDIP and MIDAS datasets also recorded the child's CHI number at the time of data collection (this was pre-populated on the CHS 6-8WR).

Sections 2.3.9.1 to 2.3.9.5 describes datasets held by ISD: Child Health Systems Programme Pre-School 6-8 Week Review (CHS 6-8WR); National Dental Inspection Programme (NDIP); General / Acute Inpatient and Day Case – Scottish Morbidity Records (SMR01); Child Health Systems Programme – School Primary One Screening (CHSP-S); and Management Information and Dental Accounting System (MIDAS).

Sections 2.3.9.6 to 2.3.9.12 describes datasets held by COH at the University of Glasgow (Health Visitor Caries Risk Assessment; Dental Health Support Worker – First Visit; Dental Health Support Worker Courtesy Visit; DHSW Record of Child / Parent Contact; Dental Health Support Worker Childsmile Practice; Invitation to Childsmile and Childsmile Dental Practice).

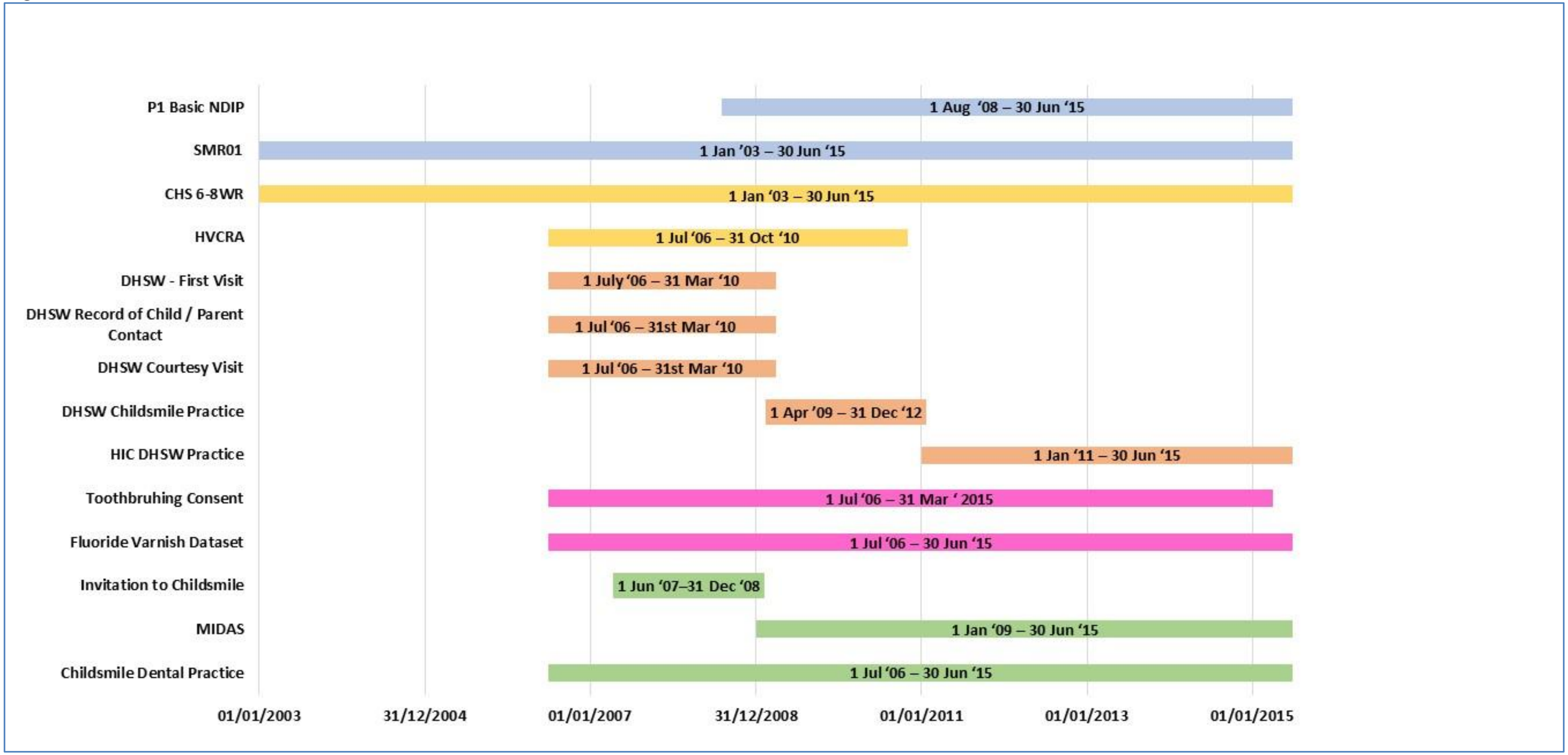
Sections 2.3.9.13 to 2.3.9.16 describes data held by HIC at the University of Dundee (Toothbrushing Consent; Fluoride Varnish Visit; Heath Informatics Centre DHSW Practice Interventions).

Figure 2-2 is a Gantt chart that details the time line of each dataset identified for inclusion in the Safe Haven i.e. the start and end date that a particular dataset was in operation. The NDIP, SMR01, CHS 6-8WR, MIDAS, Fluoride Varnish Visit, Heath Informatics Centre DHSW Practice Interventions, and Childsmile Dental Practice datasets that continue to the end of the Gantt chart do not have an end date as they are all dynamic datasets and are still in use.

Figure 2-3 is a flow chart of the Childsmile Pathway highlighting the potential stages in a child's Childsmile experience for data collection.

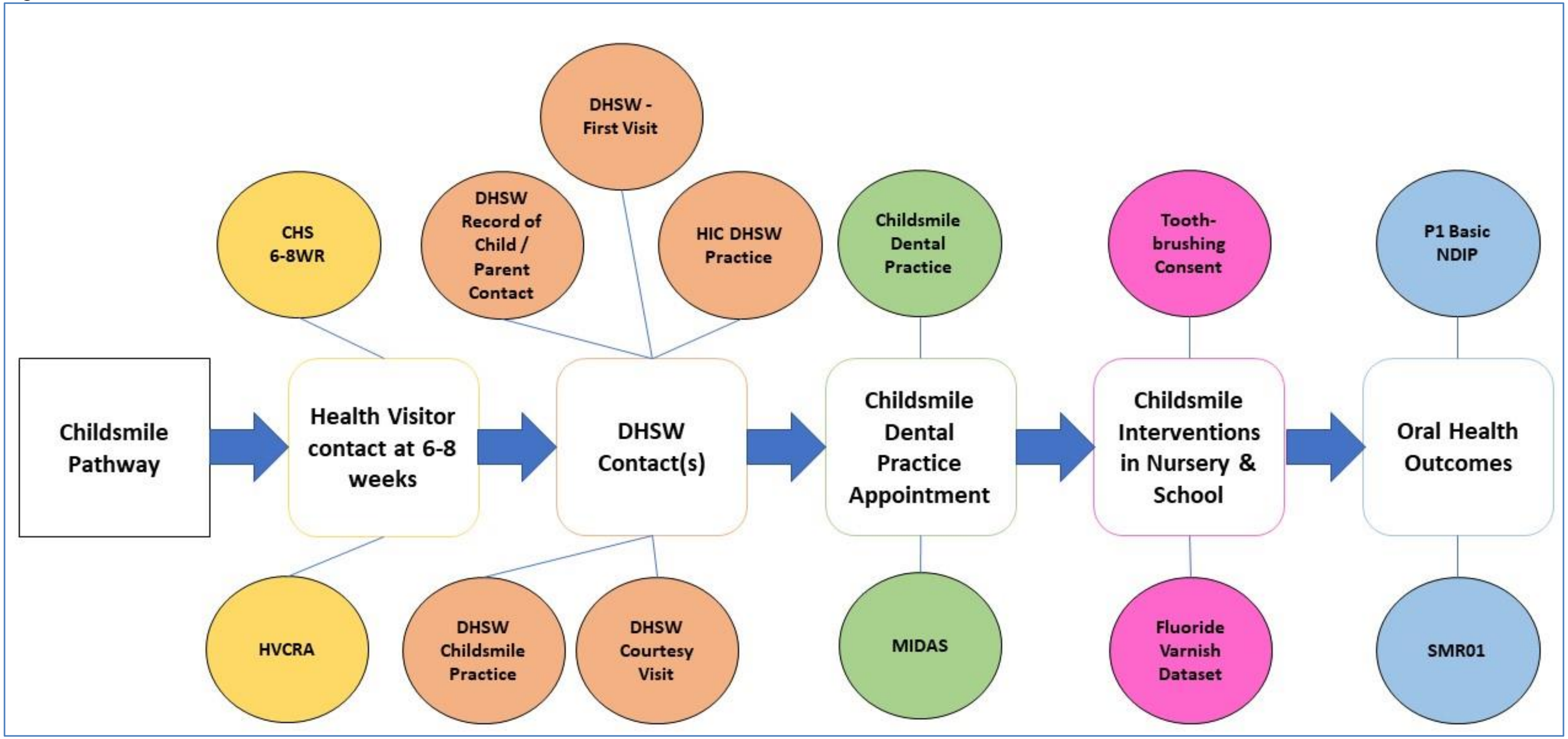
In both Figures 2-2 and 2-3, datasets in blue are those than can be used to measure a health outcome, yellow datasets are data collected by health visitors, orange datasets are Childsmile interventions delivered by a Dental Health Support Worker, pink datasets are Childsmile interventions delivered in nursery and school and green datasets are Childsmile interventions delivered in dental practices.

Figure 2-2: Childsmile Data Form Gantt Chart



P1 – Primary One; NDIP - National Dental Inspection Programme; SMR01 – General / Acute Inpatient and Day Case – Scottish Morbidity Record; CHS 6-8WR -Child Health Systems Programme Pre-School 6-8 Week Review; HVCRA – Health Visitors Caries Risk Assessment Form; DHSW – Dental Health Support Worker; HIC – Health Informatics Centre; MIDAS – Management Information and Dental Accounting System

Figure 2-3: Childsmile Data Form Flowchart



P1 – Primary One; NDIP - National Dental Inspection Programme; SMR01 – General / Acute Inpatient and Day Case – Scottish Morbidity Record; CHS 6-8WR -Child Health Systems Programme Pre-School 6-8 Week Review; HVCRA – Health Visitors Caries Risk Assessment Form; DHSW – Dental Health Support Worker; HIC – Health Informatics Centre; MIDAS – Management Information and Dental Accounting System

2.3.9.1 Child Health Systems Programme Pre-School 6-8 Week Review

The Child Health Systems Programme Pre-School 6-8 Week Review (CHS 6-8WR) is the universal child health surveillance system that was launched for health visitor's in 1991. It was established in most Scottish health boards by 2001 although some health boards were not part of this system until later (NHS Western Isles in 2006, NHS Highland in 2007, NHS Shetland in 2008 and NHS Grampian and NHS Orkney in 2010). The CHS 6-8WR is normally carried out by a Health Visitor or a General Practitioner when the child is aged between six and eight weeks old. A range of health and social information relating to a child's development is recorded via the CHS 6-8WR.

In 2011, a section relating to the assessment of a child's dental health support requirement (i.e. whether or not they were referred to a Childsmile Dental Health Support Worker (DHSW) was added to the form).

Once the form is completed, a paper copy is sent to the local health board Child Health Systems team. The Child Health Systems team then code the form onto the Child Health System database stored within ISD. Each row of the data represents an individual child's CHS 6-8WR.

A 2010 audit (Wood and Stirling, 2010) indicated that ISD had not received a CHS 6-8WR record for 6% of children that were registered at a GP practice (a figure that was consistent across time). The proposed reasons for ISD not receiving the record include the following: the child was being treated in a Special Care Baby Unit so did not receive a CHS 6-8WR, the parents of the child refused to participate or could not be contacted, or that a CHS 6-8WR was completed but the form was lost or not processed. Children who lived in areas of high deprivation were less likely to have received a CHS 6-8WR, which suggests that children and families most at need of support from a Health Visitor were the least likely to be seen. This was described as an example of the inverse care law (Wood et al., 2012).

The CHS 6-8WR dataset formed the 'index' dataset for this Childsmile evaluation study i.e. for all records in the other datasets to be used in the study, there must be a matching record within the CHS 6-8WR dataset (Section 2.3.10.1).

2.3.9.2 National Dental Inspection Programme

The National Dental Inspection Programme (NDIP) is a series of annual dental inspections of school children that attend Local Authority schools in Scotland. There are two types of inspections. The first type is an annual basic inspection which is intended for every P1 (five to six years old) and P7 (11 to 12 years old) child at a Local Authority School; and a detailed epidemiological inspection that alternates annually between either P1 or P7 children and which is selected as a representative sample (approximately 20%) of that section of the population.

The P1 Basic Inspection is comprised of a simple examination of a child's teeth and is performed by a trained dental professional within the school setting. The child is normally five or six-years-old although it is possible for some children to be aged four at the date of inspection. As a result of their current oral health status or dental treatment requirement, the child is then put into one of three categories. If the child has an abscess or serious dental caries, they are put into Category A and a standardised letter sent to the child's parent or carers advising them that their child 'should seek immediate dental care'. If the child does not show any symptoms that are required for classification into Category A but shows signs of 'history of tooth decay, a broken or damaged front tooth, tooth wear, poor oral hygiene or may require orthodontics' then they are classified as Category B, and a different letter was sent to the child's parents or carers advising them to 'seek dental care in the near future'. If the child has not been categorised into either A or B, they are deemed to have no obvious caries experience (Category C) and a letter sent to their parents or carers advising them that their child 'should continue to see the family dentist on a regular basis'. These wordings, which was used in the above letters, relates to what was used at the time of the 2015 Basic NDIP (ISD Scotland, 2015). The wording has since been changed (Macpherson et al., 2018).

Consent for both the Detailed and Basic NDIP inspections are 'negative consent' i.e. children are automatically consented for the inspection and are only withdrawn from the inspection if instructed by their parent or carer.

The NDIP data are entered onto a laptop computer at the point of inspection. When the laptop computer is connected to an NHS network point, the data are uploaded to the local health board server. When the inspections are completed for the school year, the data are sent by secure file transfer to ISD. ISD then provided each health board with data quality and completion reports. For example, improbable dates and postcodes that are not contained on ISD's SIMD postcode lookup file (Section 2.3.8). Health boards can check these errors with the child's school before resubmitting the correct data to ISD.

NDIP data relating to individual children are available in ISD from the 2008/2009 school year onwards (historic data were analysed by the University of Dundee). The most current NDIP results available at the time of data extraction were for the 2012/2013 school year inspections thus giving four 'years' of data. The proportion of eligible children receiving a P1 Basic Inspection ranged from 85% in the 2008/2009 school year (Merrett et al., 2009), to 92% in the 2011/2012 school year (Macpherson et al., 2012). Although the target set by the Scottish Government was for all P1 (and P7) children attending a Local Authority school to have a Basic Inspection, it was improbable that this could happen due to children being unable or refusing to participate, children being absent from school on the date of inspection, or the parent actively refusing consent (Macpherson et al., 2010b).

The P7 Basic Inspections data were not included in Phase One because all children with a P7 Basic Inspection data available would have been born between 1st March 1997 and 28th February 2002. This was prior to the cut-off date for inclusion in the baseline dataset i.e. born on or after 1st January 2003. It should also be noted that because the delivery of Childsmile interventions did not begin until July 2006, children with a 2012/13 or earlier P7 Basic Inspection would have been too old to have received the Childsmile interventions.

The Detailed Inspection data were excluded because they represented only a small population sample (approximately 20%) compared to the much more comprehensive coverage that is provided by the Basic Inspection (85%-92%) of children attending a Local Authority School. The Detailed Inspection also alternates annually between P1 and P7 children therefore the data were only available every second year for each age group unlike the Basic Inspection where data were collected annually for both age groups.

With the largest coverage expected, the P1 Basic NDIP dataset was identified as the primary outcome measure for this study. This measures the level of dental caries experience at five years of age and can be related to the level and nature of Childsmile interventions received prior to the inspection.

2.3.9.3 General / Acute Inpatient and Day case – Scottish Morbidity Record

The General / Acute Inpatient and Day case – Scottish Morbidity Record (SMR01) dataset records all hospital inpatient and day cases in Scotland. Each SMR01 record is recorded by individual patient and episodes. Each record for an episode is produced when a patient finishes an episode of care for reasons such as being discharged from care, reassigned to a different clinician, an alteration of specialty, or death (ISD Scotland, 2019b).

Each record includes information on:

i. The date that a patient was admitted to hospital for that episode and the location of the hospital.

ii. The condition that they were admitted for as recorded by the International Statistical Classification of Diseases and Related Health Problems 10th Revision [ICD-10] Diagnosis Codes.

iii. Any surgical treatment administered as recorded by the Office of Population Censuses and Survey Classification of Interventions and Procedures version 4 [OPCS-4] Procedure Codes.

All of the dental treatments that were performed in hospitals as inpatient and day case procedures, including dental extractions that were performed under general anaesthesia, were specified.

SMR01 data have been collected since 1960 and were computerised in 1968. SMR01 data are received by ISD within six weeks of the patient being discharged from hospital. Each individual row of data within the SMR01 database is at the individual patient level and is specific to each time a patient is admitted to hospital. Therefore, if a patient had two or more separate incidents of hospitalisation, then there would be two or more individual rows of data for each corresponding incident. If there are multiple Diagnosis or Procedure Codes at an individual hospitalisation episode, these codes are recorded on the same row of the dataset.

When the SMR01 episode is being recorded, the data are validated locally before being submitted to ISD where further validation checks are undertaken (ISD Scotland, 2019a). Examples of data validation checks that are relevant to the fields used in this study is that the admission date must be later than the date of birth and that a hospital location must be provided. SMR01 had no known systematic data issues and had a high level of completeness (Administrative Data Liaison Service, 2015). The completeness of the ‘Main Condition’ and ‘Main Operation/Procedure’ has remained consistent over the previous twenty-five years at 89% and 94% respectively (NHS National Services Scotland, 2015a).

As the parameters of the Childsmile evaluation did not include linking records to non-dental procedures, only episodes that had an OPCS-4 Procedure Code or an ICD-10 Diagnosis code relating to dentistry were included for the Childsmile evaluation study.

2.3.9.4 Child Health Systems Programme – School Primary One Screening

The Child Health Systems Programme – School Primary One Screening (CHSP-S) is a universal review of Primary One children (aged four to six-years-of-age). Data collected included the weight and height of the child as well as any other health or wellbeing problems identified. The data are collected by health staff working within schools. It was piloted in 1995 and was established in most health boards by 2008 although NHS Orkney was not part of the system until 2010.

Data collected via this system has been used to produce statistics for the Body Mass Index of Primary One children in Scotland (ISD Scotland, 2018b). In 2001/2002, 21% of children in Scotland had a review but this rose to 94% in 2011/2012 once the review was available in every health board in Scotland.

2.3.9.5 Management Information and Dental Accounting System

The Management Information and Dental Accounting System (MIDAS) is the system by which dentists in Scotland are paid for providing NHS dental treatments, including Childsmile Interventions which was first recorded on MIDAS on the 1st January 2009 as a pilot (rolled out from October 2011). It is also used to record all patient registrations with an NHS dentist. Dental practices submit claims for payment relating to NHS dental treatment and patient registrations on a ‘GP17 form’. This form is used by dentists to record NHS treatments and to claim financial remuneration for these treatments. The completed form is submitted to the Practitioner Services Division either electronically or by post. Practitioner Services Division are a division of NSS that ensures dental treatment is being delivered correctly and who also process payments to dental practitioners for the services they have provided. MIDAS data are subsequently stored within the NSS data warehouse which was accessed by ISD. Data quality is extremely high for this dataset as the information submitted by the dental practice is required for the practice to be reimbursed for treatment they have delivered as well as for clinical governance processes. PSD performs a high level of quality checks (including financial and quality probity checks via the Dental Reference Service) and dental practitioners are informed of any errors in the data provided so that it can be corrected (ISD Scotland, 2013). The list of treatment items available for practitioners to claim are detailed on the Statement of Dental Remuneration (the primary care dental contract) (Scottish Government, 2019a), although the number of treatments that are available for children’s teeth is quite limited. Childsmile interventions were incorporated into the Statement of Dental Remuneration in October 2011 (Scottish Government, 2011b).

Dental practitioners record the start and end date of a treatment, the type of treatment received and a count of the number of items of a particular treatment received at that visit on the GP17 form. If a patient received more than one type of treatment or intervention at an appointment, or if a course of treatment was delivered over multiple appointments, this is all recorded on one GP17 form. The location of the dental practice is recorded via a Location Code, a unique ID assigned to individual dental practices. The List Number, a unique ID number that is assigned to an individual dentist working at an individual practice, is also entered on the form to record which dentist was providing the treatment (or was responsible for the patient when the treatment was delivered by a dental nurse or hygienist). Dentists that work at more than one dental practice have a separate list number for each dental practice and individual dentists can be identified by a unique ID (based on their General Dental Council number) to ensure individuals can be identified.

For registration data, the dental practice records the date of registration (or if they were already registered, the date of the most recent contact/treatment) on the GP17 form as well as the List Number of the dentist and Location Number of the practice.

Data for treatments and registrations for this study were extracted and provided as two separate datasets respectively. The extracted MIDAS treatment dataset was one of the multiple datasets that were used to calculate the degree of Childsmile interventions that each child received. The Childsmile interventions that are conducted in the dental practice and captured via MIDAS included ‘tooth brushing instruction’, ‘dietary advice’ and ‘application of topical fluoride’.

2.3.9.6 University of Glasgow Community Oral Health Section Datasets

During the demonstration phase of the programme from 2006 to 2010, a series of bespoke forms were developed to facilitate and capture Childsmile activity in the West of Scotland (NHS Ayrshire & Arran, NHS Lanarkshire and NHS Greater Glasgow & Clyde).

These datasets held (controlled) by the University of Glasgow Community Oral Health Department (COH) included: Health Visitor Caries Risk Assessment, Dental Health Support Worker – First Visit, DHSW Record of Child / Parent Contact, and DHSW Childsmile Practice which were paper forms collected in relation to the Health Visitor and DHSW component, and the dental practice component. The process for collecting, data entry and quality checking these data sets was completed by the University of Glasgow’s COH team. A paper copy of each completed form was submitted to COH. The forms were firstly checked by COH for any missing or incorrect data. The forms were then entered into a Microsoft Access database to create an electronic database of each type of form. The persons responsible for completing the forms (Health Visitor, DHSW or dental practice staff) were contacted if there were any data errors and the corrected data were then entered onto the database.

The data that was entered by COH was subjected to a 10% random check in order to ensure data entry accuracy. Around 1% of forms were found to have an inaccuracy when entered onto the database, although in most cases, this was caused by spelling mistakes of the child’s name and address. There were no material errors to the content of the forms identified except for the HVCRA form which was often only partially completed by the Health Visitor, where only the personal identifiers were recorded on the form, with all other data omitted.

The COH datasets that were extracted were used along with the other intervention-related datasets to quantify the level and nature of Childsmile interventions each child received.

All forms submitted to COH should have been pre-populated with a CHI number. If CHI, or any other personal identifier was missing, a manual search of the CHI database was undertaken to locate the required data. Access to the CHI database was only for users that had been pre-approved via the ISD Caldicott Guardian and had been issued with a username and password for accessing this service.

These bespoke forms are discussed in sections 2.3.9.6 to 2.3.9.12.

2.3.9.7 Health Visitor Caries Risk Assessment Form

The Health Visitor Caries Risk Assessment form (HVCRA) was a form that was used during the Childsmile demonstration pilot project prior to the national roll-out. It was completed by Health Visitors and was in use as part of the Childsmile programme from 1st July 2006 to 31st October 2010. The HVCRA served two functions. The first function was that it allowed Health Visitors to assess a child's risk of dental caries. The second function was for the Health Visitor to refer a child, if required, to a DHSW.

The HVCRA contained four indicators that were used to assess a child's caries risk. These were 'the child lives in an area of high deprivation', 'someone in the household smokes', 'the reason for the parent/carer's last dental visit was to obtain relief of pain', 'after considering all other known caries risk factors, this child may be more likely to get tooth decay'. The guidelines provided to the Health Visitor were that if there was a positive response to at least one of these indicators then the Health Visitor should refer the child to a DHSW. The parent/carer, however, could decline the invitation. All children visited by a Health Visitor, the parent / carer were advised that the child should be seen in general dental practice in infancy.

From July 2009, caries risk indicators were no longer recorded, and the primary purpose of the form became to communicate to the DHSWs those families referred to them by the Health Visitor for additional support.

The form stopped being used in October 2010. Instead a section that recorded a child's dental health support requirement was integrated into the 'mainstream' health visitor child health systems review forms undertaken at six to eight weeks (i.e. CHS 6-8WR).

2.3.9.8 Dental Health Support Worker – First Visit

The 'Dental Health Support Worker – First Visit' form recorded the initial contact/intervention made between a DHSW and the child from the 1st July 2006 until the 31st March 2009. Although oral health support was provided to the family, the primary purpose of this form was to record the facilitation of a child to have a Childsmile dental practice appointment. A family could opt out of Childsmile at this stage and the reason for not wanting to participate would be recorded. This form was completed by the DHSW who contacted the child.

2.3.9.9 Dental Health Support Worker Courtesy Visit

The 'DHSW Courtesy Visit' form was completed by a DHSW when they contacted a family after their initial appointment with a Childsmile Dental Practice. The form recorded the answers to the questions that were asked by the DHSW about the family's experience at their first Childsmile Practice appointment as well as whether or not a second appointment to the dental practice had been scheduled. This form was active between the 1st July 2006 and the 31st March 2009.

2.3.9.10 DHSW Record of Child / Parent Contact

The purposes of the 'DHSW Record of Child / Parent Contact' form was to record all other DHSW Childsmile interventions that a child had in addition to both the initial DHSW contact and the post dental practice visit courtesy contact. It was active between the 1st July 2006 and the 31st March 2009. These contacts could either have been with a DHSW at the family home or at a clinic. These forms recorded both the kept and failed appointments as well as any oral health interventions that were delivered at the appointment.

2.3.9.11 DHSW Childsmile Practice

The DHSW Childsmile Practice form was completed by a DHSW and used between the 1st April 2009 and the 31st December 2010. It combined elements of the ‘Dental Health Support Worker – First Visit’ form, the ‘DHSW Record of Child / Parent Contact’ form and the ‘DHSW Courtesy Visit’ form meaning that all DHSW contacts were recorded on a single form. The form recorded the facilitation of a child with a Childsmile dental practice appointment (a DHSW would contact a local dental practice that was participating in Childsmile on behalf of the parents or carers to arrange a dental appointment for them) as well as any oral health interventions that were delivered by the DHSW at the contact. Parents or carers could opt out of Childsmile at this stage and the reason for not wanting to participate was recorded.

2.3.9.12 Childsmile Dental Practice

This dataset consists of collated data on Childsmile interventions provided in a dental practice setting, originating from three different data sources. The first source of the data was the Childsmile Practice Record of Child / Parent Contact Form where data relating to Childsmile appointments in the dental practice were collected between the 1st July 2006 and the 31st December 2008 which was prior to the Childsmile data being recorded on the GP17 form.

The second source of data was MIDAS. Data relating to Childsmile interventions for those practises participating in the demonstration phase from 2009 onwards were extracted by ISD and were supplied every three months to COH. This process continued once Childsmile was rolled out nationally in October 2011. Childsmile contacts from this source were already included in the separate MIDAS database (Section 2.3.9.5) i.e. this data is duplicated.

The third source is the ‘Community Dental Service’ activity data collected by the individual health boards. Starting in January 2009, during the demonstration phase, and on every third month henceforth, each health board in Scotland would submit an Excel spreadsheet of Childsmile dental practice contacts within the Community Dental (salaried) Services to COH. PSD did not process dental activity in Community Dental Services at this time as their dental activity was not related to payments (as it was a ‘salaried’ service) and therefore these data were not contained within the MIDAS dataset.

The three data sources were then collated into a format that was compatible with the MIDAS extract to create the Childsmile Dental Practice dataset and included data where applicable on: start date of treatments; the end date of treatments (MIDAS only); Childsmile interventions delivered at the appointment (‘toothbrushing instruction’, ‘dietary advice’ and ‘application of topical fluoride’) the location of the dental practice via a Location Code or other identifier; and the List Number of the dentist that provided the treatment (MIDAS only).

2.3.9.13 Health Informatics Centre Childsmile IT System

HIC provide bespoke database software for the electronic entry of Childsmile data relating to: Childsmile nursery and school supervised toothbrushing (2006 onwards), Childsmile fluoride varnish in Nursery and School (2006 onwards), and the DHSW component (2011 onwards). Data are entered directly into the HIC databases by the Childsmile Staff (DHSW, EDDN). Quality control reports are regularly generated by HIC and are made available to the regional Childsmile teams to resolve any outstanding data issues.

The HIC Childsmile IT system is a large single database that consisted of the multiple smaller datasets described in Sections 2.3.9.14 to 2.3.9.16. These are supplied to ISD by HIC every four months as part of the routine collection of Childsmile data by ISD. Once the process of uploading the whole HIC database into the Safe Haven is completed, it is partitioned back into the smaller datasets, based on the different Childsmile components and datasets. This process is described in Section 2.6.6.

The partitioned datasets will be used along with the other Childsmile intervention-related datasets to analyse the nature and extent of Childsmile interventions each child received over their life course.

2.3.9.14 HIC DHSW Practice Interventions (Community Based Interventions)

From January 2011 onwards (post-demonstration period), all DHSW child contacts as part of the Childsmile Practice community-based element of the programme were recorded on the HIC Childsmile IT system. These data included:

i. Name of the DHSW visiting the family.

ii. Appointment date.

iii. Type of visit (‘clinic’, ‘home visit’, ‘other’ or ‘telephone).

iv. Method of referral to the DHSW (‘Health Visitor referral’, ‘clinic’ or ‘other’).

v. Type of visit (‘clinic’, ‘home visit’, ‘other’ or ‘telephone’; the result of the visit (‘declined’, ‘no entry’, or ‘success’), and if the visit was declined, the reason for this.

vi. For those appointments that were a ‘success’, details of the oral health interventions delivered at the contact were included along with outcomes such as the family being facilitated with a dental appointment or continued home visit support with the DHSW.

vii. Finally, a series of actions determined by the result of the appointment were recorded such as: re-contacting and rescheduling appointments where the appointment was not a success; referral back to a Health Visitor; or if the family were making their own dental arrangements and no further input was required from the DHSW.

2.3.9.15 Toothbrushing Consent

The Toothbrushing Consent database included the data relating to a child’s consent onto the nursery and school supervised toothbrushing component of Childsmile and included data that were collected between July 2006 and March 2015. The parents and carers of children that attended participating establishments were provided with a paper form to provide signed consent for their child to participate in the supervised toothbrushing intervention at the child’s nursery or school. Completed consent forms were returned to local Childsmile staff via the nursery or school and the corresponding data were entered by Childsmile staff into the HIC Childsmile IT system. It included the date of consent and if the child was consented or not (although the reason for non-consent was not recorded).

2.3.9.16 Fluoride Varnish Visit

The Fluoride Varnish Visit dataset related to the application of Fluoride Varnish to children as part of the Childsmile Nursery and School Programme. Collected from July 2006 during the demonstration phase in the East of Scotland, then from 2011 onwards nationally, the data included:

i. Consent information.

ii. Date of intended application.

iii. Whether or not fluoride varnish was applied and the reason if no varnish was applied.

iv. Extended Duty Dental Nurse that applied the fluoride varnish.

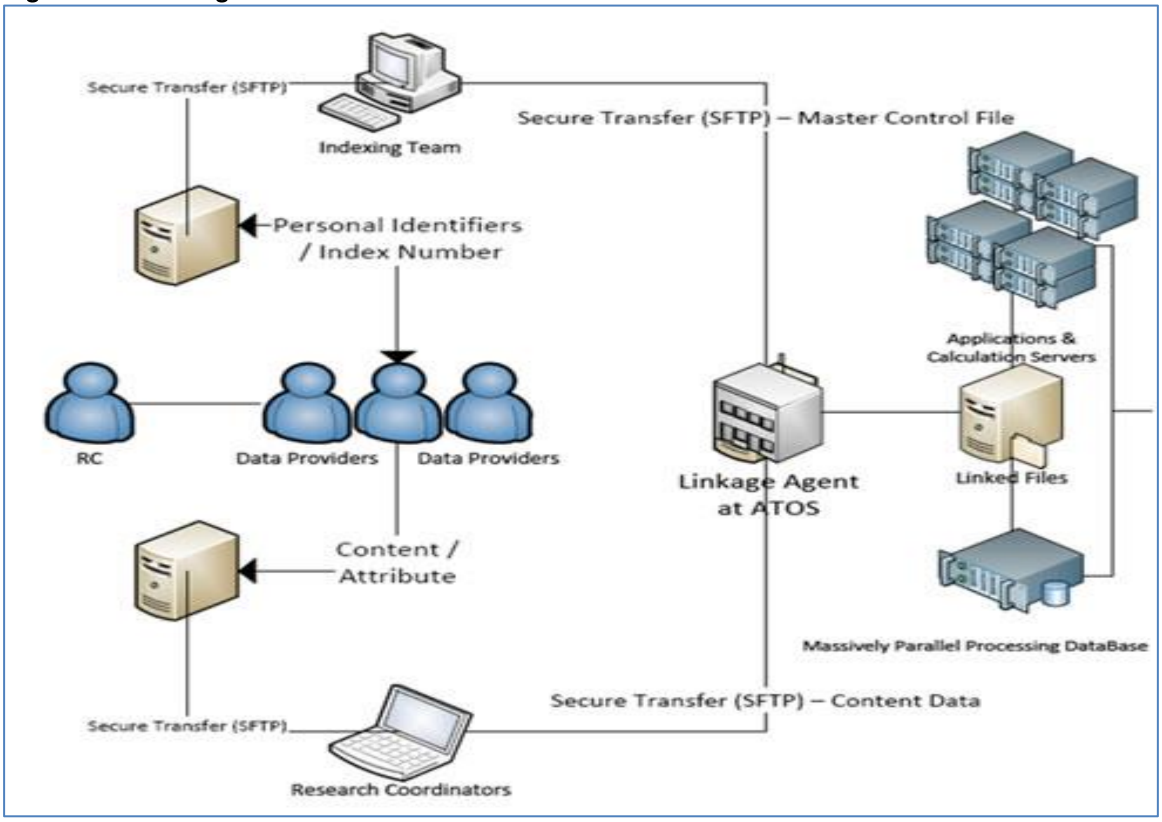
v. Were the parent/carer of the child was issued with a dental referral letter informing them of additional dental needs and the reason for the referral letter.

DHSWs entered the data related to this Childsmile intervention at the time of the nursery or school visit directly into the HIC Childsmile IT system as part of their support to the Extended Duty Dental Nurses (EDDN) who apply the fluoride varnish.

2.3.10 Transfer of Linkable Datasets into Safe Haven - Phase One

Sections 2.3.10.1 to 2.3.10.7 describe the process of securely transferring individual child level data with identifiers from the data providers to the Safe Haven as anonymised but linkable datasets. This process is also summarised in Figure 2-4 (ISD Scotland, 2010). The processes described forthwith in sections 2.3.10.1 to 2.3.10.7 are to ensure that identifiable variables in each dataset (such as name) are kept separate from their corresponding ‘content’ i.e. the non-identifiable variables such as those that record the details of a Childsmile intervention contact. The methods mentioned in this section undertaken by COH were all completed solely by the author of this thesis.

Figure 2-4: Linkage Process for NHS NSS Safe Haven



Extracted from (ISD Scotland, 2010)

2.3.10.1 Source Dataset Inclusion Criteria (Phase One)

At Phase One, the CHS 6-8WR dataset was chosen as the baseline 'index' dataset to be used as the inclusion criteria for records in all the other datasets that were to be used in the study. That is, only those records in each of the other datasets with a corresponding CHS 6-8WR record were included in each dataset extract. The CHS 6-8WR was chosen as the baseline dataset as these records are obtained when a child was approximately six to eight weeks old and therefore was a proxy-baseline for a birth cohort. It comprised of children born between the 1st January 2003 and the 31st December 2012 with a CHS 6-8WR record.

The advantage of the Child Health System data is that the CHI numbers are generated at source i.e. health service registration and therefore the CHI is complete, and no CHI seeding is required.

A list of all CHI numbers in the baseline dataset were provided by NSS ISD Child Health Team to the ISD Indexing Team, a department within NSS ISD that processes CHI matching, with no other variables included.

2.3.10.2 Transfer of COH Datasets from COH to Indexing Team in ISD

As all children in the COH datasets were born within the date of birth time-frame of the baseline dataset, for each of the seven datasets held by COH, an extract was generated for every record in each of the datasets. These extracts contained only CHI numbers and a unique local reference number. These seven datasets were sent as separate files by a Secure File Transfer Protocol (SFTP) GlobalSCAPE, an NHS approved online data transfer service, to the Indexing Team. To use the SFTP, two emails were sent from the Indexing Team via the SFTP, the first with a username and the second was a password so that each of the files could be uploaded into SFTP and transferred securely to the Indexing Team. A document entitled *Data Providers Spec Process* was provided by eDRIS which detailed the format in which the files and their corresponding data were to be sent to the Indexing Team.

1. Each file must be in CSV format.

2. Each variable had to have a fixed width with details of the width of each variable provided in a separate Microsoft Excel file.

3. Files had to be sent delimited with details of the delimiter provided in a separate document.

2.3.10.3 Indexing and Transfer of COH Datasets from Indexing Team back to COH

The ISD Indexing Team processed each of the COH files to replace the CHI numbers with a unique study person ID. The unique study person ID was unique to each individual child in each individual dataset so if a child had records in two or more COH datasets, the unique study person ID would be different in each. This was to ensure that records from differing datasets could not be linked outside of the Safe Haven. If a data provider did have access to two or more of the datasets which could be linked, this in turn could lead to breaches of data confidentiality and protection – one of the main principles of the Safe Haven is to ensure data confidentiality and for results only to be released from the Safe Haven after disclosure checks have been undertaken. If a child had more than one record in an individual database, the unique study person ID would remain the same within the individual database. These updated files were then retuned via the SFTP using the process described to COH.

2.3.10.4 Transfer of COH Datasets from COH to Linkage Agent

For each of the seven datasets held by COH, a series of new extracts containing the unique local reference number along with the 'content' variables that were approved for use in the Safe Haven was generated. Using the unique local reference number in both these extracts and the returned files from the indexing team, the corresponding files were linked, and the unique study person ID appended onto each record of the content data. The unique local reference number was then removed from the files.

Using the SFTP, these updated files were sent to eDRIS using the method described in Section 2.3.10.2. These files were processed directly by a Linkage Agent. This was an automated system which picked up the files from the SFTP folder and processed them through the Linkage Agent without any manual intervention.

2.3.10.5 Upload of COH Linkable Datasets into Safe Haven via Linkage Agent

The Indexing Team uploaded a 'key' to the linkage agent, an automated computer programme (ISD Scotland, 2018c), that contained a list of each unique study person ID and a corresponding index number- a linkage ID that was unique for each child with at least one record in any of the databases being uploaded into the Safe Haven. Using the key within the Linkage Agent, the unique study person ID was removed from the files and replaced with an index number. This index number could then be used to link matching records across the multiple datasets within the Safe Haven.

The Indexing Team also uploaded a file into the Linkage Agent containing the index numbers of the children in the baseline dataset. This was linked to the COH files and only those in the COH file with a matching index number in the baseline dataset were uploaded into the Safe Haven. This final stage ensured that it was not possible for data providers to know which records in their files have corresponding records in datasets not under their ownership. In this instance, it meant that COH did not know which children in their datasets also had a CHS 6-8WR record.

Once this process was complete, the COH databases were then securely uploaded into the Safe Haven containing only the index number and the dataset's 'content'. These index numbers subsequently allowed for data analysis work to be undertaken in the Safe Haven by providing a variable by which each child could be linked across each of the datasets as required.

2.3.10.6 Data Processing within COH

All of the data processing and linkage procedures that were undertaken by COH in preparation of the seven datasets being uploaded into the Safe Haven were undertaken using a series of computer programmes written in SAS Enterprise Guide Version 5.1.

2.3.10.7 Health Informatics Centre and National Services Scotland Information Services Division Datasets

The datasets used in the study provided by HIC and NSS ISD data controllers were uploaded into the Safe Haven using the same procedure as described in Sections 2.3.10.1 to 2.3.10.5. As ISD were already routinely provided with and stored copies of the full HIC datasets, ISD processed and provided the HIC dataset for the Safe Haven rather than HIC. For all of these datasets, the extracts were only for children born between 1st January 2003 and 31st December 2012 as per the baseline index dataset. The uploading of all datasets into the Safe Haven was completed in May 2014.

2.4 Phase One Source Data Linkage: Validation, Completeness and Quality

2.4.1 Linkage Validation – Phase One

To validate the linkage process, dates of birth in the CHS 6-8WR dataset were compared with the dates of birth of records with matching index numbers in the other datasets uploaded into the Safe Haven. Of the 193,843 P1 NDIP records with a matching CHS 6-8WR index number, 22% of the dates of birth did not match across the two datasets. For all other datasets, the dates of birth match rate was >99%. The non-matching dates of birth were manually checked by the thesis author, and for all the datasets except the P1 NDIP, the majority of unmatched dates of birth could be explained by typos in the entry of date of birth e.g. the 1st January 2006 instead of the 10th January 2006. The majority of non-matching P1 NDIP dates of birth could not be explained by typos. Further comparison of other variables that could be compared such as gender provided a similar match rate of >99% for all the datasets excluding the P1 NDIP which had a match rate of ~50%. It was therefore concluded that the linkage was valid for all the datasets except the P1 NDIP. The error with the P1 NDIP was reported to eDRIS in February 2015. It was reported back by eDRIS that they could not isolate the cause of the error, but it suggested that the error was most likely to have occurred when the unique study person ID in the returned files from the indexing team to the data provider was appended to the content data (Section 2.3.10.3).

2.4.2 Data Completeness and Quality – Phase One

To measure the completeness of the datasets uploaded into the Safe Haven, the data contained within each of the datasets were to be compared with appropriate published data such as birth records, NDIP reports and Childsmile Headline reports.

As an initial measure of the completeness of the CHS 6-8WR dataset, the total numbers of children with a CHS 6-8WR record were compared annually with the corresponding annual Scottish Birth Data (National Records of Scotland, 2018b).

Table 2-2 indicates that between 2003 and 2012 85% of births in Scotland had a corresponding CHS 6-8WR. The total number of children without a CHS 6-8WR record was substantially higher than the expected 6% as reported in Wood and Stirling's audit of missing CHS 6-8WR records (2010). This issue was reported back to the Child Health Systems team via eDRIS. The response from Child Health Systems team was that although all health boards would have been completing a CHS 6-8WR in this time frame, not all were recording in the national system until 2010 when the last health boards began using the national child health surveillance system (Section 2.3.9.1). This was reflected in Table 2-2 where there was a substitutional difference in the percentage rates from 2010 onwards compared to the earlier years. For both 2011 and 2012, the rate of births without a corresponding CHS 6-8WR was much closer to the expected 6%.

Table 2-2: Frequency of CHS 6-8WR records compared to Scottish Birth Records (Phase One)

Year of Birth	Birth Records in Published Report (B)	Children with a CHS 6-8WR record	% of B
2003	52,432	41,946	(80%)
2004	53,957	43,705	(81%)
2005	54,386	43,509	(80%)
2006	55,690	44,552	(80%)
2007	57,781	47,380	(82%)
2008	60,041	49,834	(83%)
2009	59,046	49,599	(84%)
2010	58,791	53,450	(91%)
2011	58,590	55,075	(94%)
2012	58,027	53,965	(93%)
Total	568,741	48,015	(85%)

As an initial measure of the completeness of the P1 NDIP dataset, the total numbers of children in each school year of the P1 NDIP from 2008/2009 to 2011/2012 were compared with the corresponding NDIP reports from these years.

Table 2-3: Frequency of P1 children with a P1 NDIP inspection (Phase One)

NDIP School Year	Total Number of P1 Children Inspected in Published Reports (n)	Inspected P1 children in Uploaded Dataset	% of n
2008/2009	45,126	35,363	(78%)
2009/2010	48,606	38,009	(78%)
2010/2011	47,712	38,416	(82%)
2011/2012	50,204	39,831	(79%)
Total	191,648	15,1619	(79%)

Table 2-3 indicates that in each school year from 2008/2009 to 2011/2012, approximately 20% of children reported to have received a P1 NDIP inspection in the published reports were not within the uploaded P1 NDIP dataset (Merrett et al., 2009; Macpherson et al., 2010b; Macpherson et al., 2011; Macpherson et al., 2012).

Due to a greater number of children than expected missing CHS 6-8WR and P1 NDIP records, coupled with the index number error on the P1 NDIP dataset, no further data quality completeness or checks relating to this study were undertaken using the Phase One datasets and the analyses could not continue as planned.

2.5 Phase One Summary

Due to the serious quality and completeness concerns, particularly around P1 NDIP which was to be used as the primary outcome measure of the study, it was not possible to carry out any further linkage in the Safe Haven until the P1 NDIP file had been updated. A separate data linkage study was undertaken using the uploaded datasets that did not require the P1 NDIP data that measured the effectiveness of the role of DHSW with regards to dental participation (Hodgins et al., 2018). Thus, this work was not in vain and ensured that the work that was undertaken during Phase One was utilised. Nevertheless, this was a major setback for the outcome evaluation of Childsmile.

Due to the CHS 6-8WR dataset being the baseline dataset that the other datasets extracts were based upon, it was important that CHS 6-8WR had a high level of completeness. As it was not until 2010 that every health board in Scotland was fully using the national system to record CHS 6-8WR, this would have resulted in lower than expected numbers of children in the other datasets extracted for use in the Safe Haven. This was reflected in the lack of completeness of the P1 NDIP data which would have covered births from 1st March 2003 to 28th February 2007 and therefore well before there was full national coverage of the CHS 6-8WR data.

It was concluded that utilising the CHS 6-8WR data was not a robust method for establishing the cohort upon, especially when it resulted in large sections of the outcome dataset being excluded.

An alternative option for trying to improve the coverage of the datasets would be to use the P1 NDIP as a retrospective indexing dataset, although this would exclude all children who did not have an NDIP inspection record for reasons such as no longer residing in Scotland, or attending a non-Local Authority School, but had received Childsmile interventions. A second option was to establish the cohort based on including children who were in the CHS 6-8WR dataset and/or P1 NDIP, thus capturing a larger portion of children either from birth or at the study end point. This second alternative method would offer the best opportunity to maximise the index dataset to capture a greater number of children that would have received Childsmile interventions in comparison to the other two methods. It should be considered, however, that the dataset would still not be fully complete because any child who did not have either a CHS 6-8WR or a P1 NDIP would still be excluded (e.g. a child not born in Scotland or who attended a non-local authority school).

With both the errors in the P1 NDIP linkage, and the exclusion of large chunks of data due to the baseline dataset, a complete data refresh with updated and more recent data for every dataset in the study was proposed which was scheduled for a new ‘Phase Two’.

There was great level of working knowledge gained by the author throughout Phase One. This included the processes of gaining ethical and Information Governance approvals, the methods for providing anonymised datasets for inclusion in the Safe Haven, and the greater understanding of the datasets, and the potential problems associated with them, along with the developed quality and completeness checking procedures. These methods were pivotal for assuring the success of the study in Phase Two.

The piloting of the remote Safe Haven and resolution of the problems encountered with the software was not only valuable for the continued use of the national remote Safe Haven for the Childsmile evaluation but was also beneficial for other future users. It can also be concluded from Phase One that it is feasible to link and access complex big datasets in the secure Safe Haven environment with its built-in software and analysis tools. The knowledge gained during this phase further emphasised the importance of running early quality checks on datasets.

Thus, the initial plan of undertaking a baseline (Phase One) analysis with a subsequent refresh/update with subsequent years of data at Phase Two was now not possible. Phase One was in effect a pilot of data linkage methods and testing of feasibility, and Phase Two is the main study.

2.6 Phase Two Methods

This Section describes the methods of Phase Two which consists of the:

i. Processes of gaining updated consent to access and link multiple individual child level datasets to progress with the outcome analysis of Childsmile.

ii. Updated linkage processes of the source datasets; the sharing and uploading of the refreshed source datasets into the Safe Haven.

iii. Initial primary analysis of the datasets to validate the linkage process.

iv. Selection of a single cohort year from the outcome dataset to be used for the overall initial analysis of Childsmile.

v. Further primary analysis of the datasets to validate and measure the quality and completeness of their variables and categories.

The time-period for Phase Two was from April 2015 to December 2018.

2.6.1 Information Governance Approval – Phase Two

As discussed in Section 2.5, an alternative method for assembling a baseline dataset to maximise the number of children that could be captured within it was required. A baseline dataset that contained children who had a record in the CHS 6-8WR dataset and/or P1 NDIP was chosen as it captured children both prospectively and retrospectively thus maximising the number of children available to the study.

A new information governance approval application was developed due to:

i) Changes in the baseline dataset.

ii) Other ongoing data linkage projects that required additional datasets.

iii) A need for more recent data for every dataset in the study not previously requested.

iv) Changes to the named users who would be accessing the data.

Prior applications for approvals had been submitted to the Privacy Advisory Committee (PAC) but from May 2015, PAC was superseded by the Public Benefit and Privacy Panel for Health and Social Care (PBPP) (Public Benefit and Privacy Panel for Health, 2015).

An application form was submitted to PBPP in October 2015. Like the previous PAC application, this was an all-encompassing application that detailed the multiple branches of the evaluation. Alongside a request for approval, the application included:

1) Names of the users that would be accessing the data and their then current information governance training status.

2) An overview of the study including a description of why it was needed, along with its aims and objectives and envisaged benefits to the public and/or patients, as well as a concise outline of the proposal design. It listed: data sources; inclusion/exclusion criteria; relevant date range; and the need for identifiable or potentially identifiable data.

3) Proposed duration of the study, (given as five years) and proposed requirements for updated data at regular intervals (given as once during the five-year process, two to three years into the process).

4) Details of ethical approvals.

5) The Safe Haven that the requested data were to be accessed through.

6) A list of the datasets and the variables that were required including the period they would cover (e.g. all NDIP inspections from 2008 to 2015) and whether the variables were required for processing only (e.g. child's postcode which was not required after SIMD data had been linked to the postcode).

The application was approved by PBPP in November 2015 and valid for five years from the date of approval (Appendix 5). In December 2015, an amendment to the proposal that requested additional NDIP variables was approved by PBPP (although there was no formal letter issued with regards to this approval with the approval sent by email from the PBPP Panel Manager to the eDRIS Coordinator).

2.6.2 Ethical Approval – Phase Two

Updated clarification that the study did not require NHS ethical approval was granted in March 2015 from the West of Scotland Research Ethics Service Office's Scientific Officer because 'the project is research using only data obtained as part of usual care but note the requirement for PAC approval to permit sharing or publication of anonymised data obtained from patients under the care of NHS Scotland' (Appendix 6).

An ethics application entitled *Childsmile: the national oral health programme for Scotland; Evaluation and development project: Phase II* was submitted to the University of Glasgow's College of Medical, Veterinary and Life Sciences Ethics Committee for Non-Clinical Research Involving Human Subjects in January 2016. Ethical approval was granted in January 2016 (Appendix 7). This was an all-encompassing application that detailed the multiple branches of the Childsmile evaluation. This particular research project was included within the ethics application and therefore was approved as part of the overall ethical approval for the evaluation of Childsmile.

2.6.3 Edinburgh Parallel Computing Centre Safe Haven

On the 8th November 2015, the NHS NSS National Safe Haven secure research portal provided by AtoS Safe Haven was taken down and replaced by a new NHS NSS National Safe Haven provided by the Edinburgh Parallel Computing Centre (EPCC). Access to the new EPCC Safe Haven environment was initially to be available from the 17th November 2015. However, this was delayed until 17th December 2015. During this down time, study workspace files were transferred from the AtoS Safe Haven environment to the EPCC Safe Haven environment. eDRIS continued to support researchers accessing the National Safe Haven.

EPCC operated a 'bring your own licence' policy which applied to any software required for a researcher's work within the Safe Haven (e.g. MS Office, SAS and

SPSS) so rather than EPCC purchasing individual software licences for each user of their Safe Haven, users were able to use their own institution licences.

2.6.3.1 Updated 'Approved Researcher' Status

To maintain 'approved researcher' status, each individual member of the Childsmile data linkage team had to sign an updated eDRIS User Agreement and complete an approved additional Information Governance course. The author of this thesis completed an e-learning course assessment for Scotland provided by the Medical Research Council entitled *Research Data and Confidentiality e-Learning Course* in May 2015 which was valid for three years (Appendix 8). The course was completed again in April 2018 which was valid for a further three years (Appendix 9).

2.6.3.2 Installation and Access to Remote Safe Haven Desktop

Remote access to the new National Safe Haven was available via accredited IP addresses (UK universities, NHS and Scottish Government). Users provided a mobile telephone number to their eDRIS coordinator who in turn provided a username and password (sent via separate emails for data security purposes) for accessing study areas within the Safe Haven. A document was provided by eDRIS detailing how to connect to the new Safe Haven. This document included a URL to access the Safe Haven login webpage. A pop-up box would appear on screen for the user to enter their username. A pin code valid for one session was then automatically sent to the previously provided phone number via SMS which was entered into the pop-up box. A new screen was generated for entering the username and password. This launched the Safe Haven Virtual Machine from which the study data and software could be accessed. Unlike the Safe Haven that was supplied by AtoS, no problems with regards to accessing or using the Safe Haven were encountered.

2.6.4 Description of Datasets – Phase Two

Updated versions of the datasets described in Sections 2.3.9.1 to 2.3.9.16 were requested for use in the study with no additional datasets required. For NDIP, this included two additional years of inspection data (2013/2014 and 2014/2015). For each of the other datasets, additional records up to 30th June 2015 were available.

2.6.4.1 SIMD 2009

A review of whether multiple versions of SIMD were required as part of Phase Two was undertaken. Guidance from *The Deprivation for Analysts* document (National Services Scotland, 2017) indicated that if a study is measuring the impact of health interventions that are predominantly targeted towards patients living in areas of deprivation then it is a single SIMD version that should be used. Multiple versions of SIMD would be required when measuring inequality and changes to this over time. As this study is not analysing Childsmile's impact on inequalities over time but rather its impact on inequalities in the improvement of oral health i.e. impact on SIMD 1 (the most deprived quintile) versus SIMD 5 (the least deprived quintile) the former method of using one SIMD version was chosen. The disadvantage of this method is that the deprivation status of a data zone may change with time so what was once a data zone in the most deprived decile may have moved to a less deprived decile and vice versa.

Further guidance in this document indicted that the SIMD version that was published closest to the point that the intervention started should be chosen. As most children in the study would have been born in 2009 and therefore were eligible for Childsmile interventions from 2009 onwards, SIMD 2009 version 2 was chosen as the most appropriate.

The SIMD 2009 variables were only assigned to the P1 NDIP due to this dataset providing the outcome measure for this study.

2.6.5 Phase Two Transfer of Linkable Datasets into Safe Haven

The process of securely transferring individual child level data with identifiers from data providers to the Safe Haven as anonymised linkable datasets is described in detail in Sections 2.3.10.1 to 2.3.10.7. The only process that was different in Phase Two was the inclusion criteria of the source dataset.

2.6.5.1 Source Dataset Inclusion Criteria (Phase Two)

In Phase Two, the index dataset consisted of all children with either a CHS 6-8WR record (children born between 1st January 2003 and 30th June 2015) **or** an NDIP record from 2008/2009 to 2014/2015 inclusive. These datasets were chosen to form the index cohort dataset as the CHS 6-8WR are obtained when a child was approximately six to eight weeks old and therefore was almost a birth cohort whereas the NDIP records are obtained when the child is approximately five years old and would capture children who did not receive a CHS 6-8WR due to reasons such as migrating to Scotland at later date. Using NDIP as part of the index cohort maximised the number of children with an outcome measure.

This index cohort dataset was used as the inclusion criteria for records in all of the other datasets to be used in the study. That is, only those records in each of the other databases with either a corresponding CHS 6-8WR or a NDIP record were included in extracts from these databases.

2.6.6 Health Informatics Centre Database Management

The stacked HIC database that was described in Section 2.3.9.13 was extremely large (5GB). The size of the dataset would result in the SAS software taking up to half an hour to upload the dataset each time it was to be analysed, when in comparison, the other datasets in the study could be uploaded in seconds. To make the HIC dataset more user-friendly, once it was initially uploaded into SAS, individual extracts of the smaller datasets described in Sections 2.3.8.14 to 2.3.8.16 were generated and used henceforth and the HIC dataset was made redundant.

2.7 Phase Two Source Data Linkage: Validation, Completeness and Quality

2.7.1 Linkage Validation

To validate the linkage process, dates of birth in the CHS 6-8WR were compared with the dates of birth of records with matching index numbers in the other datasets that had been uploaded into the Safe Haven. This process was repeated comparing the dates of births in the P1 NDIP dataset with the other datasets in the Safe Haven.

Table 2-4 shows that when comparing the dates of birth of matching records in both the CHS 6-8WR and the P1 NDIP with the corresponding index numbers in the other study datasets, the match rate for the CHS 6-8WR was >98% for all datasets and >95% for the P1 NDIP, although for the majority of the datasets linked to the P1 NDIP, the match was >=98%.

The match rates were consistently 1-2% higher for each dataset when linked to the CHS 6-8WR in comparison to P1 NDIP. As the CHI number and date of birth was pre-populated on the CHS 6-8WR which originated from the source CHI database, a higher level of accuracy would be expected compared to that of the P1 NDIP where the CHI was assigned to each record by means of probability matching and the date of birth was manually recorded by inspection team coordinators in health boards from school rolls.

Cleaning of the date of birth variable for all datasets in the study was undertaken and this process is described in Section 2.7.3.

Table 2-4: Frequency of 6-WA and P1 NDIP records matching study datasets

Dataset	Total Records in Linked Dataset (a)	Unique Index Numbers in linked dataset (b)		Unique Index Numbers in linked dataset and 6-8 Week Assessment (c)		Unique Index Numbers with Matching DOB in 6-8 Week Assessment (d)		Unique Index Numbers in linked dataset and P1 NDIP (e)		Unique Index Numbers with Matching DOB in P1 NDIP (f)	
	n	n	% of a	n	% of b	n	% of c	n	% of b	n	% of e
CHS 6-8WR	962,592	962,592	(100)	-	-	-	-	286,400	(77)	281,065	(98)
P1 NDIP	381,696	374,001	(98)	286,400	(77)	281,065	(98)	-	-	-	-
SMR01	127,141	106,552	(84)	89,726	(84)	89,002	(99)	33,917	(32)	33,200	(98)
MIDAS (treatments)	13,886,563	918,789	(7)	764,253	(83)	764,253	(100)	311,029	(34)	305,253	(98)
MIDAS (Registrations)	13,875,904	1,049,635	(8)	874,754	(83)	874,754	(100)	361,640	(34)	354,917	(98)
HVCRA	46,829	45,171	(96)	41,565	(92)	41,231	(99)	36,738	(81)	35,985	(98)
DHSW – First Visit	10,980	10,797	(98)	9,800	(91)	9,735	(99)	9,963	(92)	9,747	(98)
Record of Child / Parent Contact	899	871	(97)	799	(92)	796	(>99)	793	(91)	779	(98)
DHSW Childsmile Practice	18,448	15,092	(82)	13,731	(91)	13,602	(99)	13,223	(88)	12,940	(98)

Table 2-4 Continued

Dataset	Total Records in Linked Dataset (a)	Unique Index Numbers in linked dataset (b)		Unique Index Numbers in linked dataset and 6-8 Week Assessment (c)		Unique Index Numbers with Matching DOB in 6-8 Week Assessment (d)		Unique Index Numbers in linked dataset and P1 NDIP (e)		Unique Index Numbers with Matching DOB in P1 NDIP (f)	
	n	n	% of a	n	% of b	n	% of c	n	% of b	n	% of e
DHSW Courtesy Visit	2,090	2,053	(99)	1,943	(94)	1,938	(>99)	1,876	(91)	1,839	(>99)
Invitation to Childsmile	1,114	1,104	(99)	1,007	(91)	1,004	(>99)	1,036	(94)	1,022	(99)
Childsmile Dental Practice	903,970	182,377	(20)	160,005	(88)	154,787	(97)	119,759	(75)	113,984	(95)
Toothbrushing Consent	629,471	420,291	(67)	350,957	(83)	343,490	(98)	252,873	(60)	245,574	(97)
Fluoride Varnish Visit	1,084,056	223,113	(21)	177,872	(80)	175,345	(99)	155,952	(70)	152,017	(97)
HIC DHSW Practice Interventions	97,676	71,415	(76)	69,471	(97)	69,443	(>99)	9,412	(14)	9,256	(98)

2.7.2 Data Completeness

To initially measure the completeness of the datasets that were uploaded into the Safe Haven, the data contained within the datasets were checked for probable dates of births i.e. date of birth <= record date (date of intervention, inspection, etc.). These were then compared to the appropriate published data such as the National Records Scotland Birth Records, NDIP reports and Childsmile Headline reports.

2.7.2.1 Comparison of CHS 6-8WR Dataset with Published Data

As an initial measure of the completeness of the CHS 6-8WR dataset, the total numbers of children with a CHS 6-8WR record were compared annually with the corresponding annual Scottish Birth Records data (National Records of Scotland, 2018b).

Between January 2003 and June 2015, 13% of births in Scotland did not have had a corresponding CHS 6-8WR (Table 2-5). As per Phase One (Section 2.4.2), this is substantially higher than the expected 6% due to the roll-out of health boards recording in the national system. From 2011 to 2014 the rates of children without a CHS 6-8WR record were at the expected rate (5-6%). For January 2015 to June 2015, 8% of births were without a CHS 6-8WR record but as there is often a lag in data being recorded on the Child Health Surveillance national system, this could in part explain this. This would have no impact on this study as children born in 2015 would not be old enough to have received an P1 NDIP inspection. As P1 NDIP data were only available from 2008/2009 onwards all pre-2003 records were reported together. This time period also pre-dates the implementation of the CHS 6-8WR in the majority of health boards.

Table 2-5: Frequency of CHS 6-8WR records compared to Scottish Birth Records (Phase 2)

Year of birth	Birth Records in Published Report (B)	Children with a CHS 6-8WR Record	% of B
1990-2002	771,905	348,499	(45%)
2003	52,432	41,993	(80%)
2004	53,957	43,536	(81%)
2005	54,386	43,643	(80%)
2006	55,690	44,756	(80%)
2007	57,781	47,448	(82%)
2008	60,041	49,819	(83%)
2009	59,046	49,383	(84%)
2010	58,791	53,459	(91%)
2011	58,590	55,065	(94%)
2012	58,027	54,556	(94%)
2013	56,014	52,654	(94%)
2014	56,725	53,082	(94%)
2015 (Jan-Jun)	27,036	24,699	(92%)
Total (1990- Jun 2015)	1,480,421	962,592	(65%)
Total (2003- Jun 2015)	708,516	614,093	(87%)

2.7.2.2 Comparison of P1 NDIP Dataset with Published Reports

To initially measure the completeness of P1 NDIP dataset (Table 2-6), data for the total number of P1 children in Local Authority schools, total number of P1 children inspected in Scotland, and the proportion of basic NDIP inspection letters distributed in Scotland were taken from the annual published NDIP reports from 2008/2009 to 2014/2015 (Merrett et al., 2009; Macpherson et al., 2010b; Macpherson et al., 2011; Macpherson et al., 2012; Macpherson et al., 2013b; Macpherson et al., 2014). The published data were compared to the total number of P1 children with an NDIP inspection within the uploaded source dataset. Within the reported data, the total number of P1 children in Local Authority Schools is a population estimate of all five-year-old children in Scotland at the time of publication rather than an accurate count of the total number of P1 children in Local Authority schools as it includes children attending non-Local Authority Schools. The data in the Table 2-6 are presented by academic years (1st July – 30th June).

The total number of P1 children inspected in the uploaded source dataset (n) is an accurate representation of the published reports with 99% of the number of children in the published reports within the dataset. The dataset also has 88% of the five-year-old population estimate compared to the 89% as recorded in the published reports. For each NDIP cohort year in the dataset in the Safe Haven, the proportion of A (‘seek immediate dental care’), B (‘seek dental care in the near future’) and C (‘continue to see the family dentist on a regular basis’) letters distributed in Scotland consistently matches that within the published reports.

Table 2-6: Frequency of P1 children with a P1 NDIP inspection (Phase Two)

Academic year	Total Number of P1 children in Local Authority schools (a)	Total number of P1 children inspected in Scotland (b)		Total number of P1 children inspected in uploaded P1 NDIP Dataset (c)			Proportion of Basic Inspection letters distributed in Scotland in Published Reports			Proportion of Basic Inspection letters distributed in uploaded P1 NDIP Dataset		
	n	n	% of a	n	% of a	% of b	A*	B**	C***	A*	B**	C***
2008/2009	53,135	45,126	(85%)	44,692	(84%)	(99%)	(11%)	(27%)	(62%)	(11%)	(27%)	(62%)
2009/2010	54,854	48,606	(89%)	47,429	(86%)	(>99%)	(10%)	(27%)	(63%)	(10%)	(27%)	(63%)
2010/2011	55,763	47,712	(86%)	47,958	(86%)	(>100%)	(10%)	(26%)	(65%)	(10%)	(26%)	(65%)
2011/2012	54,865	50,204	(92%)	49,722	(91%)	(99%)	(9%)	(26%)	(66%)	(9%)	(26%)	(65%)
2012/2013	56,446	51,573	(91%)	51,269	(91%)	(99%)	(9%)	(25%)	(66%)	(9%)	(24%)	(66%)
2013/2014	57,021	52,439	(92%)	52,220	(92%)	(>99%)	(9%)	(24%)	(67%)	(9%)	(24%)	(67%)
2014/2015	59,457	52,579	(88%)	52,386	(88%)	(>99%)	(8%)	(22%)	(70%)	(8%)	(22%)	(70%)
Total	391,541	348,239	(89%)	345,676	(88%)	(99%)	-	-	-	-	-	-

***Seek immediate dental care; **Seek dental care in the near future; ***Continue to see the family dentist on a regular basis**

2.7.2.3 Comparison of Fluoride Varnish Visit Dataset with Published Reports

To validate the completeness of the uploaded Fluoride Varnish Visit dataset, the frequency of fluoride varnishes applied in nursery and school settings in this source dataset were compared with the published rates in the *Childsmile National Headline Data* reports (Central Evaluation & Research Team, 2012; Central Evaluation & Research Team, 2015) (Table 2-7). In 2006/2007, there were n = 20 more children in the dataset than in the reported data. A possible explanation for this was that additional data were added to the HIC database after the report was generated as it was a dynamic dataset. The total number of fluoride varnish applications was 93% of that in the published reports. This rate reflects the number of children in the index datasets (CHS 6-8WR and P1 NDIP) in comparison to the respective population estimates (Tables 2-5 and 2-6), which therefore validates the completeness of the Fluoride Varnish Visit dataset with regards to the total number of records contained within it.

Table 2-7: Fluoride varnish application rates for nursery and school children in Fluoride Varnish Dataset versus published data

Academic Year	Published (N)	Dataset (n)	% of N
2006/2007	2,020	2,040	(101%)
2007/2008	8,705	7,841	(90%)
2008/2009	23,276	21,383	(92%)
2009/2010	43,100	40,071	(93%)
2010/2011	89,963	82,073	(91%)
2011/2012	138,137	127,966	(93%)
2012/2013	199,074	185,574	(93%)
2013/2014	241,183	223,655	(93%)
2014/2015	241,062	228,973	(95%)
Total	986,520	919,576	(93%)

2.7.2.4 Comparison of MIDAS Treatment and Childsmile Dental Practice Datasets with Published Reports

Childsmile interventions delivered in dental practices were captured in both the MIDAS Treatment and Childsmile Dental Practice datasets. Therefore, to calculate the true amount of each of the three interventions (fluoride varnish applications, toothbrushing instruction, and dietary advice) within the data uploaded into the Safe Haven, the two datasets were combined, and unique interventions were isolated.

The annual rates of Childsmile interventions delivered in dental practices for children in the source datasets were compared with the published figures in the *Childsmile National Headline Data* reports (Central Evaluation & Research Team, 2011; Central Evaluation & Research Team, 2015) to check the combined completeness of the MIDAS Treatment and Childsmile Dental Practice datasets (Table 2-8). The data in this table are presented by financial years (1st April – 31st March). Aside from 2006/2007 – 2007/2008 when the delivery of Childsmile interventions within dental practice settings was in its infancy, the annual rates of each intervention within the source datasets in comparison to the published data were fairly consistent across all three interventions.

From 2009/2010 to 2012/2013, the rate of fluoride varnish applications in the source datasets ranged from 99% to 103% in comparison to the reported figures in the Childsmile Headline Data reports. As rates similar to Childsmile Nursery and School were expected, the data providers (COH and ISD), were contacted. Two explanations were given for the higher than expected rates. The first was that the data provided for the published reports were extracted at a time point close to the end of the academic year whereas dental practitioners can still submit GP17 forms detailing fluoride varnish application after this time (up to 3 months). The second explanation was that COH exclude children from the *Childsmile National Headline Data* report where there was not a CHI number available which accounts for around 2% of the records, whereas the quality of the data may have improved with time, due to MIDAS being a dynamic database, resulting in these records being assigned a CHI and therefore could be linked to an index number for inclusion in the study.

Childsmile interventions delivered within dental practices prior to 2009/2010 relate to data collected before the recording of Childsmile dental practice activity on GP17 forms. Therefore, it is expected that data for these years would not be as accurate as the later years when the method of collecting these data was standardised across the whole of Scotland via GP17. In 2014/2015, the rates drop to 93% although this is not surprising as the proportion of the five-year-old child population contained within the P1 NDIP dataset was considerably lower for this year than the previous three years (Table 2-6) and therefore this drop in the intervention rates for 2014/2015 is reflective of the index datasets.

Table 2-8: Childsmile intervention rates in dental practices for children in source datasets versus published reports

Financial Year	Children receiving fluoride varnish applications in dental practice			Children receiving toothbrushing instruction in dental practice			Children receiving dietary advice in dental practice		
	Published (n)	**Datasets**	**% of n**	**Published (n)**	**Datasets**	**% of n**	**Published (n)**	**Datasets**	**% of n**
2006/2007	0	0	-	1,142	1,020	(89%)	1,109	1,063	(96%)
2007/2008	42	37	(88%)	3,568	3,398	(95%)	3,745	3,552	(95%)
2008/2009	341	321	(94%)	5,083	4,791	(94%)	5,482	5,114	(93%)
2009/2010	2,291	2,261	(99%)	10,816	10,419	(96%)	11,624	11,293	(97%)
2010/2011	8,255	8,520	(103%)	22,335	23,275	(104%)	23,405	24,258	(104%)
2011/2012	36,803	36,860	(100%)	66,352	65,519	(99%)	68,079	67,230	(99%)
2012/2013	61,375	60,938	(99%)	98,137	95,831	(98%)	98,744	96,397	(98%)
2013/2014	70,519	67,801	(96%)	111,613	106,133	(95%)	111,677	106,174	(95%)
2014/2015	75,883	70,575	(94%)	121,072	112,431	(93%)	120,343	111,746	(93%)
Total	255,509	247,313	(97%)	440,118	422,817	(96%)	444,208	426,827	(96%)

2.7.2.5 Comparison of DHSW Datasets with Published Reports

The ‘Dental Health Support Worker – First Visit’, ‘DHSW Record of Child / Parent Contact’, ‘DHSW Childsmile Practice’ and ‘HIC DHSW Practice Interventions’ datasets all collected data on DHSW contacts with a child. Therefore, the number of successful contacts between children and a DHSW were calculated by combining all four of these datasets.

The annual rates of children successfully being contacted by a DHSW (for those records with a valid contact date i.e. contact date after date of birth) were compared with the published figures in the *Childsmile National Headline Data* reports (Central Evaluation & Research Team, 2012; Central Evaluation & Research Team, 2015) to validate the combined completeness of the four DHSW datasets (Table 2-9). The data in this table is presented by financial years (1st April – 31st March).

Table 2-9: DHSW successful contacts in source datasets versus published data

Financial Year	Reported (N)	Datasets (n)	% of N
2006/2007	2,066	1,428	(69%)
2007/2008	4,113	2,901	(71%)
2008/2009	4,893	4,975	(102%)
2009/2010	12,542	8,260	(66%)
2010/2011	17,917	12,941	(72%)
2011/2012	14,100	12,754	(90%)
2012/2013	14,557	12,832	(88%)
2013/2014	12,721	11,045	(87%)
2014/2015	13,671	11,799	(86%)
Total	96,580	78,935	(82%)

From 2006/2007 – 2010/2011 (excluding 2008/2009), the annual rates of successful DHSW contacts were considerably lower than the published data indicating a potential error for the datasets covering this time period. Further investigation indicated that the ‘Dental Health Support Worker – First Visit’ and ‘DHSW Childsmile Practice’ datasets had 37% and 14% of records respectively with a DHSW contact date recorded as being prior to the child's date of birth (Table 2-10).

Table 2-10: Children in source datasets with a DHSW successful contact by Age

Dataset	Age: zero and above		Age: below zero		Total
DHSW – First Visit	6,975	(63%)	4,016	(37%)	10,991
DHSW Record of Child / Parent Contact	904	(>99%)	4	(<1%)	908
DHSW Childsmile Practice	12,185	(86%)	1,925	(14%)	14,110
DHSW Courtesy Visit	2,080	(>99%)	10	(<1%)	2,090
HIC DHSW Practice Interventions	69,677	(>99%)	329	(<1%)	70,006
Total	91,821	(94%)	6,274	(6%)	98,105

As these records would have been excluded from Table 2-9 and were used in the same time-period (July 2006 to December 2010) this could explain the lower than expected rates for these time periods. This issue was reported back to COH, as the data providers of these two datasets, in September 2018. COH confirmed that there was an error in the extraction of the datasets that resulted in the incorrect intervention data (including date of contact) being assigned to the records in both the 'Dental Health Support Worker – First Visit', 'DHSW Childsmile Practice' datasets as well as the 'DHSW Record of Child / Parent Contact' dataset. COH also confirmed that this error was isolated to these three datasets. COH resolved this error and the corrected datasets were uploaded into the Safe Haven in October 2018. The date of contact was checked against the child's date of birth for the three updated datasets with Table 2-11 indicating that the error had been resolved with <99% of records for all three datasets having a date of birth prior to the date of contact

Table 2-11: Children in source datasets (updated datasets) with a DHSW successful contact by Age

Dataset	Age: zero and above		Age: below zero		Total
Dental Health Support Worker – First Visit	10,937	(>99%)	43	(<1%)	10,991
DHSW Record of Child / Parent Contact	887	(>99%)	1	(<1%)	908
DHSW Childsmile Practice	14,078	(>99%)	21	(<1%)	14,110
DHSW Courtesy Visit	2,080	(>99%)	10	(<1%)	2,090
HIC DHSW Practice Interventions	69,677	(>99%)	329	(<1%)	70,006
Total	97,659	(>99%)	404	(<1%)	98,105

Using the corrected datasets along with the 'Practice Interventions' dataset, the annual rates of children successfully contacted by a DHSW were compared with the published figures in the *Childsmile National Headline Data* reports (Central Evaluation & Research Team, 2012; Central Evaluation & Research Team, 2015) to validate the combined completeness of the four DHSW datasets (Table 2-12).

The data in this table are presented by financial years (1st April – 31st March). From 2006/2007 to 2008/2009 there are more records in the Safe Haven than in the published reports. This was due to the published data for these years only counting one record per financial year rather than every individual contact. The published data did not include data from the DHSW Courtesy Visit or the DHSW Record of Child / Parent Contact forms. After accounting for these differences, 2006/2007 and 2008/2009 figures were below 100% and in an acceptable range. 2007/2008 remained above 100% but this may be due to improvements in data quality since the time of publication. In 2010/2011, the rate of contacts in the datasets was at 77%. There was a total of 17,917 contacts reported in the published data, which is considerably higher than both the year prior total and all of the following years. It is possible that there was an error with the published data as there was no spike in births in 2010 or 2011 (Table 2-5) which could have resulted in more children being contacted by a DHSW. Further to this, the number of DHSW contacts in the Safe Haven for 2010/2011 is similar to that of the two following years, further supporting the hypothesis that the figures in the Safe Haven datasets are correct and that the more likely point of error is in the published data.

Table 2-12: DHSW successful contacts in source datasets (updated datasets) versus published data

Financial Year	Published (N)	DHSW Datasets (n)	% of N	DHSW Datasets after adjustment (D)	% of D
2006/2007	2,066	2,722	(132%)	2,001*	(97%)
2007/2008	4,113	5,939	(144%)	4,286*	(104%)
2008/2009	4,893	5,096	(104%)	4,503*	(92%)
2009/2010	12,542	11,907	(95%)	11,907	(95%)
2010/2011	17,917	13,874	(77%)	13,874	(77%)
2011/2012	14,100	13,650	(97%)	13,650	(97%)
2012/2013	14,557	13,852	(95%)	13,852	(95%)
2013/2014	12,721	12,015	(94%)	12,015	(94%)
2014/2015	13,671	12,727	(90%)	12,272	(90%)
Total	96,580	83,795	(87%)	88,815	(87%)

*** Only one contact per financial year counted**

2.7.2.6 Toothbrushing Consent, HVCRA and Invitation to Childsmile Datasets

There are currently no published data available on toothbrushing consent rates in Scotland and without a suitable baseline, it was not possible to check the rates of consent within the Toothbrushing Consent Dataset, however, the checking of other datasets provided by HIC found that the datasets were similar when compared to the published data and there was no reason to suspect that this dataset would be any different.

Similarly, there were no comparable published data available to compare rates of referral into Childsmile via a Health Visitor or direct from a dental practice. It was therefore not possible to check the number of children in the Health Visitor Caries Risk Assessment (HVCRA) and Invitation to Childsmile datasets with published data. As described in Section 2.7.2.7, however, these datasets were outwith the scope of the thesis study and therefore there was no further requirement for quality checks to be undertaken on these datasets.

2.7.2.7 Database Exclusion

The General / Acute Inpatient and Day Case Morbidity Record (SMR01), MIDAS Registration and Child Health Systems Programme – School Primary One Screening (CHSP-S) datasets were uploaded into the Safe Haven as part of the development of a research structure for potential future Childsmile outcome analyses rather than for analysis for this thesis. Aside from the date of birth variable in the MIDAS Registration dataset that was used to validate the dates of birth in the study datasets, all variables from SMR01, MIDAS Registrations and CHSP-S datasets were not included in the present study.

Prior to the onset of the study, COH were aware that the data quality and completeness of the HVCRA database was poor. It was concluded that the method of referral into Childsmile and any caries risks that were identified at the time of birth were not going to be analysed in relation to an oral health outcome, and that there was no further requirement for this dataset in the study. As the method of referral was not to be analysed at this time, there was also no further requirement for the CHS 6-8WR dataset aside from the date of birth variable. A separate study undertaken by Hodgins et al. (2018) utilised the CHS 6-8WR dataset uploaded into the Safe Haven by investigating the method of referral into Childsmile in relation to attendance at a dental practice as a health outcome.

2.7.3 P1 NDIP Date of Birth and Indexing Match Weight Checks

As shown in Table 2-4, the CHS 6-8WR has a 100% date of birth match rate with both the MIDAS Treatments and MIDAS Registration. This indicates that the date of birth variable in all three of these datasets is of a high accuracy and quality and it can be expected that all of these dates of birth are therefore correct. Due to this, a date of birth ‘look up’ was generated using all three of these datasets to maximise the volume of correct date of births available (Table 2-13).

Table 2-13: Combinations of datasets to generate date of birth lookup

Source of Date of Birth	n	(%)
CHS 6-8WR only	83,683	(7%)
MIDAS Treatments only	1,293	(<1%)
MIDAS Registrations only	21,638	(2%)
CHS 6-8WR & MIDAS Treatments	4,155	(<1%)
CHS 6-8WR & Registrations only	114,656	(10%)
MIDAS Treatments & MIDAS Registrations	153,243	(13%)
CHS 6-8WR, MIDAS Treatments & MIDAS Registrations	760,098	(67%)
Total Records	1,138,766	-
Total Unique Children	381,696	-

The P1 NDIP dataset was the only dataset that contained an indexing match weight (Section 2.3.7) and data relating to CHI seeding result for P1 NDIP was requested from ISD (Table 2-14).

As date of birth contributed towards the match weight total, a comparison of matching dates of birth between the date of birth lookup and the P1 NDIP by indexing match weight was undertaken. Table 2-15 indicates that when the indexing match weight is between 20 and 29, the majority of dates of birth do not match, whereas for match weights of 30 and above, the majority of dates of birth do match. For match weights of 19 and under, the majority of dates of births did match (65%) but for an indexing match weight as low as this, it is probable that only the date of birth matched and other variables such as forename and surname would not have matched.

Table 2-14: CHI Linkage Matrix for Primary 1 National Dental Inspection Programme 2008/2008 to 2014/2015

Year of NDIP Inspection	Match Weight > than 30 n	%	Match Weight < than 30		No CHI		Total
2008/2009	48,075	(99%)	421	(<1%)	312	(<1%)	48,496
2009/2010	51,684	(>99%)	262	(<1%)	216	(<1%)	51,946
2010/2011	52,314	(>99%)	259	(<1%)	229	(<1%)	52,573
2011/2012	54,331	(>99%)	243	(<1%)	203	(<1%)	54,574
2012/2013	56,757	(>99%)	154	(<1%)	169	(<1%)	56,911
2013/2014	57,115	(>99%)	134	(<1%)	107	(<1%)	57,249
2014/2015	57,279	(>99%)	128	(<1%)	126	(<1%)	57,407
Total	377,555	(99%)	1,601	(<1%)	1,362	(<1%)	380,518

Table 2-15: P1 NDIP CHI Indexing Match Weight by Date of Birth Match

Indexing Match Weight Score	DOB Match: Yes		DOB Match: No		Total
>=19	85	(65%)	45	(35%)	130
20-24	70	(16%)	376	(84%)	446
25-29	369	(37%)	617	(63%)	986
30-34	3,719	(74%)	1,293	(26%)	5,012
35-39	7,166	(68%)	3,377	(32%)	10,543
40-44	10,960	(90%)	1,230	(10%)	12,190
45-49	5,752	(98%)	135	(2%)	5,887
50-54	852	(>99%)	3	(<1%)	855
55-59	45	(100%)	0	(0%)	45
100	340,688	(>99%)	32	(<1%)	340,720
Total	369,706	(98%)	7,108	(2%)	376,814

To investigate whether the non-matching dates of birth between P1 NDIP and the date of birth lookup were the result of a data processing error when the dates of birth were manually entered into the P1 NDIP database (from the school roll data), the day, month, and year components of the dates of births that did not match were compared (Table 2-16). For match weights of 29 and below, in the majority of instances, only one component matched whereas for match weights of 30 and above, the majority had two components matching.

Table 2-16: P1 NDIP CHI Indexing Match Weight by matching Components of Date of Birth

Indexing Match Weight Score	Zero DOB Components Match		One DOB Components Match		Two DOB Components Match		Total
>=19	1	(2%)	42	(93%)	2	(4%)	45
20-24	0	(0%)	339	(90%)	37	(10%)	376
25-29	43	(7%)	437	(71%)	137	(22%)	617
30-34	57	(4%)	156	(12%)	1,080	(84%)	1,293
35-39	18	(1%)	14	(<1%)	3,345	(99%)	3,377
40-44	2	(<1%)	0	(0%)	1,228	(>99%)	1,230
45-49	0	(0%)	0	(0%)	135	(100%)	135
50-54	0	(0%)	0	(0%)	3	(>99%)	3
100	3	(9%)	14	(>99)	32	(78%)	32

All of the P1 NDIP records that were linked to CHI by the ISD Indexing Team were provided for the study regardless of their match weight. There is no gold standard cut-off match weight for when a linkage is true or false. An acceptable cut-off value can only able be determined by manually reviewing linked pairs with the cut-off value frequently established based on the weight where there are a greater number of true than false links detected (Fleming et al., 2012).

Apart from date of birth, all other variables that were used to determine the match weight were removed before being uploaded into the Safe Haven due to being identifiable (i.e. forename, surname and postcode). It can be reasonably concluded from reviewing Tables 2-15 and 2-16 that a match weight of 30 is much more likely to represent a true match between P1 NDIP records and the CHI database than those below that value. Therefore, an indexing match weight of 29 or less was chosen as the cut-off point where records would be deemed a false match and would not be included in the study. This is supported by a previous data linkage study between CHI and the National Health Service Central Register that had previously found no false matches at a match weight above 30 (Kendrick et al., 1998) although it may be possible within this study that some false matches will still remain for matches with a weight above 30.

The dates of birth in the P1 NDIP records with a match weight score of 30 and above with a matching index number but a non-matching date of birth when compared with the date of birth lookup, were replaced by the date of the birth in the lookup file. The dates of birth of P1 NDIP records with a weight score of 30 or over that did not have a matching index number was assumed at this stage to be correct as there were no further methods available to validate them (Table 2-17).

Table 2-17 P1 NDIP CHI Indexing Match Weight by matching Components of Date of Birth

P1 NDIP Total	P1 NDIP in DOB lookup		Indexing Match Weight of 30 and above		DOBs corrected	
(N)	n	% of N	m	% of N	n	% of m
381,696	376,814	(99%)	375,252	(>99%)	6,070	(2%)

2.7.4 Intervention Datasets Date of Birth Checks

The dates of birth in all the other study datasets were matched to the corresponding date of birth in the date of birth lookup. If the date of birth was not a complete match but matched on two out of three components, the date of birth was changed to that in the lookup (Table 2-18). Those records that only matched on one or less did not have the date of birth changed as the findings of Section 2.7.3 suggests that these may be false matches.

Table 2-18: Date of Birth match between Intervention Datasets and Date of Birth Lookup

Dataset	Total Records N	Non identical DOBs n	(% of N)	Corrected DOBs c	(% of n)
MIDAS Treatments & Childsmile Dental Practice	13,886,563	1310	(<1%)	809	(62%)
DHSW – First Visit	10,980	112	(1%)	57	(51%)
Record of Child / Parent Contact	899	6	(1%)	3	(50%)
DHSW Childsmile Practice	18,448	260	(1%)	143	(55%)
DHSW Courtesy Visit	2,090	8	(<1%)	6	(75%)
Toothbrushing Consent	629,471	16400	(3%)	9195	(56%)
Fluoride Varnish Visit	1,084,056	20527	(2%)	8909	(43%)
HIC DHSW Practice Interventions	97,676	239	(<1%)	38	(16%)

2.7.5 Excluded Index Numbers

After altering the dates of birth, if the date of the intervention in a record was the same as or prior to the child’s date of birth, this was deemed as improbable, and therefore it could not be determined if the intervention occurred before or after the P1 NDIP inspection date. The index numbers from each of these records were utilised to generate a list of index numbers for exclusion from the study. In addition to this, if a child was aged less than two years old at the date of fluoride varnish application, then this was also deemed as being improbable. Only children aged two or over can receive a fluoride varnish application. The index numbers of these records were added to the list of excluded index numbers.

The final step in the process was to compare the dates of births in the Childsmile intervention datasets to those in the P1 NDIP. If the date of birth was not a complete match in the matching pairs (after being cleaned in Section 2.7.4) or if it was missing from the intervention dataset, these records were classified as a false match and the index numbers were added to the list of excluded index numbers. As it was possible that the MIDAS Treatments dataset and the Childsmile Dental Practice dataset contain records related to the same intervention contact, these two datasets were merged. Table 2-4 indicated that the quality of the date of birth variable was higher in the MIDAS Treatments dataset than in the Childsmile Dental Practice dataset. Therefore, if a contact was in both datasets, only the record from MIDAS Treatment dataset was retained for this process.

The outcomes of this process are reported in Table 2-19. The DHSW – First Visit was the only dataset identified as having a potential data quality issue with regards to incorrect intervention dates with 14% of the dates being before or on a child's date of birth. This was the first dataset used to collect Childsmile data when the programme was launched in July 2006 and so the data quality issue can be potentially be equated to 'teething' problems encountered at this early stage in Childsmile. As this form had mostly been phased out by the time of this study, however, only a small number of children (n = 61) remained after this database was linked to the study cohort (Sections 2.8).

Table 2-19: Date of Birth match between Intervention Datasets and Date of Birth Lookup

Dataset	Unique Index Numbers	Unique Index Numbers Excluded for incorrect or missing DOB		Unique Index Numbers Excluded for incorrect FVA date		Unique Index Numbers excluded for incorrect intervention date	
	N	d	% of N	f	% of N	i	% of N
MIDAS Treatments & Childsmile Practice Dental Data	920,745	122	(<1%)	1,777	(<1%)	133	(<1%)
DHSW – First Visit	10,797	13	(<1%)	-	-	1559	(14%)
Record of Child / Parent Contact	871	1	(<1%)	-	-	0	(0%)
DHSW Childsmile Practice	15,092	32	(<1%)	-	-	43	(<1%)
DHSW Courtesy Visit	2,053	0	(0%)	-	-	10	(<1%)
Toothbrushing Consent	420,291	2181	(1%)	-	-	2441	(1%)
Fluoride Varnish Visit	223,113	711	(<1%)	21	(<1%)	3	(<1%)
HIC DHSW Practice Interventions	71,415	8	(<1%)	-	-	624	(1%)

2.8 Selection of Study Cohort Year

After consultation with the Childsmile Programme Executive Committee, it was decided that in Phase Two, the year group with a 2014/2015 Primary One ('five-year-old') Basic NDIP inspection would be analysed. This was the most current NDIP year of inspection available at the time of this work and it was deemed to be appropriate as it was the first year group that had been born into the nationally 'rolled out' Childsmile programme, whereas in the earlier cohort years, the full Childsmile programme was not totally operational across all the health boards and was still being piloted in some areas.

Most children with a 2014/2015 P1 NDIP record would have been born in 2009 and therefore would have been most likely to have had an opportunity to have been in contact with a DHSW in their first year of life (i.e. in 2009/2010) if deemed appropriate. In Table 2-12, the number of successful DHSW contacts nationally rises from 4,519 in 2008/2009 to 11,506 in 2009/2010 before stabilising in the subsequent year's data. This indicates that the DHSW component of Childsmile was not fully operational until 2009/2010. Similar observations can be viewed in the other elements of the Childsmile programme. The number of fluoride varnish applications in nursery and school settings rose nationally from 80,073 in 2010/2011 to 138,137 in 2011/2012 to 185,574 in 2012/13 (Table 2-7), the year children in the 2014/2015 cohort would have been of an appropriate age to start receiving fluoride varnish applications.

Childsmile dental practice claims from 2011 onwards (the year most of the children in this NDIP cohort would have been around one-year-old) were also mainstreamed when Childsmile interventions were incorporated into the Statement of Dental Remuneration in October 2011 (Scottish Government, 2011b). Thus, Childsmile was available in dental practices throughout Scotland from this time. It should be noted that it was still possible that not all elements of Childsmile were fully operating in each heath board in Scotland over the lifetime of the children in the 2014/2015 P1 NDIP cohort and there was likely variation which could be exploited in the analysis of impacts. Therefore, by selecting the most current cohort available, it allowed the study to evaluate much greater numbers of children who could have had contact with the Childsmile programme prior to the P1 NDIP inspection date.

2.9 Data Processing within the Safe Haven

Throughout both phase one and phase two, all linkage validation, completeness, cleaning and data linkage process were undertaken within the Safe Haven via SAS Enterprise Guide (version 5.1 during Phase One and version 6.2 during Phase Two).

2.10 Phase Two Summary

Phase Two utilised the working knowledge gained throughout Phase One. This ensured that the processes required for the Information Governance approvals, the uploading of anonymised datasets into the Safe Haven, and the data linkage validation / data quality / completeness checks were streamlined and completed successfully.

The new NSS National Safe Haven operated by EPCC provided a more robust and user-friendly environment for researchers to work within. Unlike in Phase One, there was no work required to perform pilot checks of access to the Safe Haven and the software within it, due to this having already being completed. There were no issues encountered with regards to accessing the Safe Haven and using the software within it.

The data linkage validation checks undertaken demonstrated that the linkage validation was successful for most of the datasets in the first instance, and those datasets where issues were identified (Dental Health Support Worker – First Visit, DHSW Childsmile Practice, and the DHSW Record of Child / Parent Contact) were promptly updated and checked to ensure the linkage was validated. Utilising the full date of birth variable, a variable that is often not available to researchers in data linkage studies (due to it being potentially disclosive) provided a robust method to validate the data linkages. The comparison of the uploaded datasets to published data reports further identified data linkage errors that had occurred, a method that may be useful to other researchers when variables such as dates of birth are not available.

Using the NDIP and CHS 6-8WR datasets provided a more robust method for establishing an index cohort than just the CHS 6-8WR alone as used in Phase One, with the number of records in the NDIP dataset providing an accurate reflection of the Primary 1 population Scotland who were eligible for a NDIP inspection. The numbers of children in the CHS 6-8WR in comparison with birth records also improved in time with 2011 to 2014 being the most accurate years.

The comparison of the intervention datasets with the published data (when available) indicated that most of the interventions in the reported data were available in the dataset extracts uploaded into the Safe Haven and that any deficiency in numbers was reflected by the accuracy of the index datasets. Although there were no published toothbrushing data available to compare the study dataset with, no problems had been identified with any of the other datasets to be used in the study that originated from HIC.

Overall, the date of birth variables were of a high quality particularly within the MIDAS and CHS 6-8WR datasets and this provided a method by which the dates of birth in the other datasets could be cleaned and corrected when appropriate. This also provided a method of establishing an accurate cut-off-point for the match weights in the NDIP dataset. The match weight was only available for the NDIP dataset but as most of the other datasets had their CHI either pre-populated or entered manually, this was not required. The 100% date of birth match rate for the two MIDAS datasets (the only other datasets where CHI was linked by means of probability matching) with the CHS 6-8WR indicated that had the match weight been available, it was likely that nearly all of the records would have had a match weight of between 35 and 100.

The 2014/2015 NDIP year was chosen as the only inspection year that would be used as an outcome measure. Although data from other previous years were available, the Childsmile programme was only in its infancy and many of the children would only have had access to part or even none of the Childsmile interventions. By choosing the most current cohort available, it allowed the study to evaluate a much greater number of children that would have potentially been in contact with the Childsmile programme.

Chapter 3 – Methods: Analysis Cohort Description and Assembly

3.1 Chapter 3 Introduction

The aim of Chapter 3 was to create and describe a cohort that would enable the evaluation of the Childsmile programme in relation to child oral health and inequalities using data at the individual child level.

3.2 Chapter 3 Objectives

The objectives of this second method chapter were to:

I. Assemble and describe a series of linked multiple datasets with high data quality and completeness; and further primary analysis of the datasets to measure the quality and completeness of their variables and categories to assess their potential for evaluating the effectiveness of the Childsmile Programme.

II. Create an outcome variable that can be used as an oral health measure for the evaluation of Childsmile.

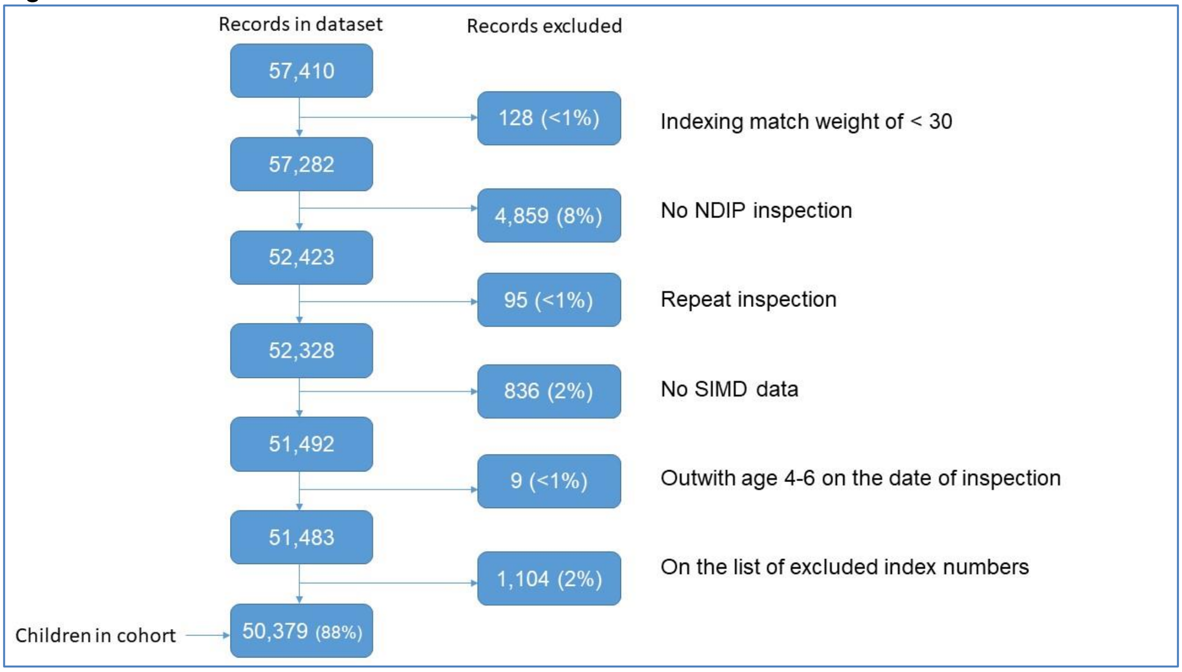
III. Data management of the source datasets so that they can be used henceforth to establish a study cohort.

IV. Describe the Childsmile Intervention variables.

3.3 Cleaning of 2014/2015 NDIP cohort

There were 57,410 P1 NDIP individual child records in the 2014/2015 cohort year. Firstly, only records with a CHI indexing match weight of 30 or greater were included resulting in 57,282 records being retained. The data were then restricted to include only those records where an inspection had been completed. All the children that were eligible for an inspection were in the database, but 8% had not had an inspection, for example if they were absent from school on the date of the inspection. This left 52,423 records. Some of these children had a repeat inspection, so the earliest inspection date was selected so that only one record per child remained (n = 52,328 children). Children were further excluded for: not having SIMD data; not falling into the four to six years age group on the date of the inspection; or for being in the list of excluded index numbers for having an improbable intervention date or a non-matching or incorrect date of birth (Section 2.7.5). At the end of this process, 50,379 children (88%) remained in the final study P1 NDIP cohort. Figure 3-1 shows a flow diagram of this process and the number of records removed at each stage. A separate dataset of the 7,031 records that were excluded from the study was also generated.

Figure 3-1: Flow Chart of Records Excluded from the 2014/2015 P1 NDIP Cohort



Therefore, included in the cohort are those children that were not on the list of excluded index numbers, had a CHI indexing match weight of thirty or greater, a completed basic NDIP inspection when they were aged between four and six, and for whom there was SIMD data available.

Selection bias associated with these processes was assessed by SIMD quintiles for each of the exclusion stages. The percentages of records removed by SIMD quintile as the exclusion process progressed were compared. Table 3-1 shows that there was no SIMD bias for records removed for each process including: i) indexing weight below 30, ii) a repeat inspection, iii) outwith four to six years age range, or iv) for having an index number contained within the list of excluded list numbers.

The number and percentage of records remaining after the exclusion of those where the inspection was not completed increased as deprivation decreased (n =

120,97 (90%) in SIMD 1 compared to 9,202 (94%) in SIMD 5). This was to be expected due to pupils living in areas of higher deprivation in Scotland being more likely to be absent from school than their more affluent peers (Scottish Government, 2018a).

In relation to their inspections, however, the proportion of A, B and C categories in the final 2014/2015 P1 NDIP cohort were compared to the published reports for the same year. In total, 8% of the cohort were in category A, 22% category B, and 70% category C. The percentages of all three categories in the cleaned data exactly matched that in the published report of 8% category A, 22% category B, and 70% category C. This indicated that the linked cohort was representative of the standard of Primary 1 children in the 2014/2015 school year.

Table 3-1: Percentages of SIMD Quintiles Remaining after Each Exclusion Stage

SIMD	Total Before Exclusion	Indexing Weight below 30		non-inspection records		Repeat inspection		SIMD Missing		Children not aged 4-6		Index Numbers in exclusion list	
SIMD Unknown	918	917	(>99)	839	(91%)	836	(>99%)	--	-	-	-	-	-
1 (most deprived)	13484	13455	(>99)	12097	(90%)	12072	(>99%)	12072	(100%)	12070	(>99%)	11777	(98%)
2	11406	11384	(>99)	10340	(91%)	10321	(>99%)	10321	(100%)	10320	(>99%)	10092	(98%)
3	10782	10758	(>99)	9841	(91%)	9820	(>99%)	9820	(100%)	9817	(>99%)	9609	(98%)
4	10973	10951	(>99)	10104	(92%)	10089	(>99%)	10089	(100%)	10087	(>99%)	9876	(98%)
5 (least deprived)	9847	9817	(>99)	9202	(94%)	9190	(>99%)	9190	(100%)	9189	(>99%)	9025	(98%)
Total	57410	57282	(>99)	52423	(92%)	52328	(>99%)	51492	(98%)	51483	(>99%)	50379	(98%)

SIMD – Scottish Index of Multiple Deprivation

3.4 Linkage of the 2014/2015 P1 NDIP Dataset to Childsmile Intervention Datasets

Records in both the ‘included’ and ‘excluded’ P1 NDIP datasets (Section 3.3) were linked by their index numbers to all corresponding index numbers in each of the Childsmile intervention datasets. The data that remained after this process were then assessed by whether it linked to the included or excluded datasets to check differences between the two groups.

3.4.1 Data Dictionary / Description of Variables in the Study Datasets

A full list of all the datasets and their corresponding variables that were uploaded into the National Safe Haven for the ongoing evaluation of the Childsmile is appended at the end of the thesis (Appendix 10). This section forms a data dictionary that describes the frequency of categories in each variable for the datasets after the linkage in Section 3.3. The P1 NDIP frequencies are reported separately for those records that were included and excluded from the 2014/2015 cohort. For the intervention datasets, the frequencies are reported firstly by records that were linked to the included 2014/2015 P1 NDIP dataset; and secondly by those that were linked to the excluded 2014/2015 P1 NDIP dataset. Where numbers were small i.e. with counts of less than five, two methods were used to report the counts to avoid releasing potentially identifiable data. The first method was to report counts of less than five as ‘<5’. In these circumstances, a second category was altered so that the true count of ‘<5’ could not be calculated via the cross-tabulation with the count of other categories/variables. For example, if the total number of records in a dataset was fifty-two and there were two variables, one with a count of two and the other with a count of fifty, the count of two would be reported as ‘<5’ and the count of fifty as ‘>47’. The second method was to pool groups of categories with counts below five to create a new pooled category with a count of greater than five. The method used was chosen on a variable by variable basis. For those variables where there were either too many categories to report individually or were potentially identifiable even after pooling, the variable was reported as ‘Complete’ or ‘Missing’.

3.4.1.1 Description of P1 NDIP Dataset

Table 3-2 describes the count of categories in each variable within the P1 NDIP, the outcome dataset in the study. These counts and percentages were computed for both the inclusion and exclusion dataset to evaluate if there were any major differences in the children included and excluded from the study.

The **'Date of Birth'** of the child; the **'Date the NDIP Exam'**; and the postcode of the school where the inspections were undertaken had a 100% completion rate. The **'Sex'** of the children was similar in both the included and excluded groups with slightly more males in both. Bar one record where the data were missing, all the records in this variable were for 'Primary 1'. There was a variable field, **'Match Weight'**, which is the CHI Indexing Match Weight and is discussed in depth in Sections 2.3.7 and 2.7.3. The cut-off match weight was 30 i.e. any match weight below thirty was excluded from the study.

The **'Health Board'** of the NDIP Inspection is the health board location of the school rather than the child. The spread of records in the categories was representative of the population spread across all the health boards in Scotland.

The **'Exam Type'** variable indicates whether the NDIP inspection was a Basic or Detailed inspection. As this dataset was for recording basic NDIP inspections, and all children who had a detailed inspection would also have a basic inspection by default, those records recorded as 'Detailed' were deemed to be 'Basic' entered incorrectly.

The **'No Exam'** variable indicates the reason why a child did not receive an NDIP inspection. The most common category in the excluded column was 'Absent' (45%) i.e. the reason a child did not receive an inspection being because they did not attend school on the day of the inspection.

The variables within Box One are indictors of the child's oral health on the day of their inspection:

Box One: Variables for recording the observations of a child's oral health

- 'A1 – Abscesses or Infection'.
- 'A2 – Gross Caries'.
- 'A3 – Obviously carious Permanent Tooth'.
- 'B1 - Obviously carious Primary Tooth'.
- 'B2 – Possibly carious Primary Tooth'.
- 'B3 – Missing Primary Molar'.
- 'B4 – Evidence of Restorations'.
- 'B5 – Poor Oral Hygiene'.
- 'C – No obvious caries experience'.

These variables were recorded as 'True' where observed, or 'False' when not observed. For these variables, it was expected that the rate of 'False' i.e. that the oral condition had not been observed, might be higher in the excluded data than in the included data. This was because all the included children had an inspection and therefore 'False' is the actual result of what was observed by the examiner. But for those excluded, 'False' also includes records recorded as 'False' because no inspection was undertaken, and this was the default value. After adjusting for this within the excluded dataset, the percentage of children observed with each of the oral health conditions was consistent with that of the included dataset, indicating no difference in oral health between the included and excluded children. For example, the percentage of 'True' for **'C – No obvious caries experience'** in the excluded group changed from 21% to 68%, which was much closer to the 70% observed in the included group.

'Overall Category' is the end result of the inspection based on the observations recorded in variables 'A1' to 'C' (Box One):

- If at least one of **'A1'**, **'A2'** or **'A3'** is 'True' then **'Overall Category'** was 'A'.

- If **'A1'**, **'A2'**, and **'A3'** are all 'False' and at least one of **'B1'**, **'B2'**, **'B3'**, **'B4', 'B5'** is 'True' then the **'Overall Category'** was 'B'.
- If **'A1'**, **'A2'**, **'A3'**, **'B1'**, **'B2'**, **'B3'**, **'B4'**, **'B5'** and are 'False' and an inspection was completed then the **'Overall Category'** is 'C' otherwise the **'Overall Category'** was 'X' i.e. no inspection was undertaken.

There was only an 'X' category recorded in the excluded dataset due to this being one of the criteria for exclusion. When considering only records with an **'Overall Category'** value of 'A', 'B' or 'C', the percentages were very similar across both the included (A = 8%, B = 22%, C = 70%) and excluded (A = 8%, B = 23%, C = 69%) datasets further indicating no difference in oral health between the two groups.

The variable **'NDIP Year'** was calculated by ISD (the data provider of the P1 NDIP dataset). It was based on the Date of NDIP Exam variable. As this variable was used as a filter to establish the linked databases, only records in the selected '2014/2015' category year remained.

The Scottish Index of Multiple Deprivation **'SIMD 2009 Version 2 Scottish Decile'** is the area-based deprivation measure of the home resident postcode of the children in the datasets with the areas of deprivation ranked at the Scottish level and categorised into deciles. The spread of children across the deciles showed higher numbers of children living in the two most deprived areas (12% and 11%) than in the least deprived areas (9% in each of the two least deprived areas) of the included dataset. This is to be expected as the population of five-year-old children in 2015 was highest in the most deprived areas (National Records of Scotland, 2018a). It could also be reasonably assumed that a higher rate of children from the more affluent areas would attend private fee-paying schools (Green et al., 2018) and therefore would not have received an inspection, as only children attending local authority schools were included in NDIP.

After accounting for the children in the excluded dataset that did receive an inspection, the percentages of categories in the P1 NDIP variables were very similar in both the included and excluded columns with no systematic bias observed. This is particularly important with regards to the oral health variables which will be used to form the outcome measure of the study where there was no difference observed between those children that were included and those that were excluded from the study.

Table 3-2: Frequency of categories within each variable of the P1 NDIP dataset, after data linkage, by records included in and excluded from the final study cohort

Variable	Included n	(%)	Excluded N	(%)
Date of Birth				
Complete	50379	(100%)	7031	(100%)
Missing	0	(0%)	0	(0%)
Date of NDIP Exam				
Complete	50379	(100%)	7031	(100%)
Missing	0	(0%)	0	(0%)
Sex				
Female	24736	(49%)	3369	(48%)
Male	25643	(51%)	3662	(52%)
School Postcode				
Complete	50379	(100%)	7031	(100%)
Missing	0	(0%)	0	(0%)
Year Group				
Primary 1	50378	(>99%)	7031	(100%)
missing	1	(<1%)	0	(0%)
Health Board of NDIP Examination				
A - NHS Ayrshire & Arran	3413	(7%)	449	(6%)
B- NHS Borders	1010	(2%)	116	(2%)
F- NHS Fife	3668	(7%)	534	(8%)
G- NHS Greater Glasgow & Clyde	10403	(21%)	1759	(25%)
H- NHS Highland	2793	(6%)	401	(6%)
L- NHS Lanarkshire	6652	(13%)	912	(13%)
N- NHS Grampian	5502	(11%)	834	(12%)
R- NHS Orkney	189	(<1%)	16	(<1%)
S- NHS Lothian	8098	(16%)	967	(14%)
T- NHS Tayside	3823	(8%)	473	(7%)
V- NHS Forth Valley	3057	(6%)	364	(5%)
W- NHS Western Isles	214	(<1%)	16	(<1%)
Y- NHS Dumfries	1346	(3%)	171	(2%)
Z- NHS Shetland	211	(<1%)	19	(<1%)
Match Weight				
17	0	(0%)	1	(<1%)
18	0	(0%)	2	(<1%)
19	0	(0%)	6	(<1%)
20	0	(0%)	5	(<1%)
21	0	(0%)	4	(<1%)
22	0	(0%)	4	(<1%)
23	0	(0%)	4	(<1%)
24	0	(0%)	9	(<1%)

Table 3-2 continued

Variable	Included n	(%)	Excluded n	(%)
Match Weight (continued)				
25	0	(0%)	14	(<1%)
26	0	(0%)	8	(<1%)
27	0	(0%)	19	(<1%)
28	0	(0%)	14	(<1%)
29	0	(0%)	25	(<1%)
30	35	(<1%)	20	(<1%)
31	111	(<1%)	15	(<1%)
32	99	(<1%)	31	(<1%)
33	100	(<1%)	25	(<1%)
34	143	(<1%)	30	(<1%)
35	139	(<1%)	23	(<1%)
36	181	(<1%)	33	(<1%)
37	221	(<1%)	28	(<1%)
38	240	(<1%)	46	(<1%)
39	215	(<1%)	41	(<1%)
40	245	(<1%)	47	(<1%)
41	247	(<1%)	44	(<1%)
42	264	(<1%)	55	(<1%)
43	255	(<1%)	51	(<1%)
44	302	(<1%)	39	(<1%)
45	213	(<1%)	47	(<1%)
46	212	(<1%)	32	(<1%)
47	134	(<1%)	30	(<1%)
48	93	(<1%)	22	(<1%)
49	82	(<1%)	11	(<1%)
50	55	(<1%)	12	(<1%)
51	38	(<1%)	6	(<1%)
52	21	(<1%)	8	(<1%)
53	14	(<1%)	2	(<1%)
54	5	(<1%)	4	(<1%)
55	9	(<1%)	0	(<1%)
56	1	(<1%)	0	(<1%)
57	1	(<1%)	4	(<1%)
58	1	(<1%)	1	(<1%)
100	46703	(93%)	6209	(88%)
No Exam				
Absent	0	(0%)	3176	(45%)
Child Refusal	0	(0%)	297	(4%)
Not Applicable	50379	(100%)	2196	(31%)
Not Attending	0	(0%)	712	(10%)
Parental Refused	0	(0%)	429	(6%)
Remove From List	0	(0%)	221	(3%)
A1 – Abscesses or Infection				
False	49637	(99%)	6995	(<99%)
True	742	(1%)	36	(1%)
A2 – Gross Caries				
False	46576	(92%)	6861	(98%)
True	3803	(8%)	170	(2%)

Table 3-2 continued

Variable	Included n	(%)	Excluded n	(%)
A3 - Obviously carious Permanent Tooth				
False	50344	(>99%)	>7026*	(>99%)*
True	35	(<1%)	<5*	(<1%)*
B1 - Obviously carious Primary Tooth				
False	39617	(79%)	6580	(94%)
True	10762	(21%)	451	(6%)
B2 - Possibly carious Permanent Tooth				
False	50295	(>99%)	>7026*	(>99%)*
True	84	(<1%)	<5*	(<1%)*
B3 - Missing Primary Molar				
False	47647	(95%)	6915	(98%)
True	2732	(5%)	116	(2%)
B4 - Evidence of Restorations				
False	45896	(91%)	6839	(97%)
True	4483	(9%)	192	(3%)
B5 - Poor Oral Health				
False	49515	(98%)	6980	(>99%)
True	864	(2%)	51	(<1%)
C - No obvious caries experience				
False	15095	(30%)	5529	(79%)
True	35284	(70%)	1502	(21%)
Overall Category				
A	4043	(8%)	180	(3%)
B	11304	(22%)	491	(7%)
C	35032	(70%)	1488	(21%)
X	0	(0%)	4872	(70%)
NDIP Year				
2014/2015	50379	(100%)	7031	(100%)

Table 3-2 continued

Variable	Included n	(%)	Excluded n	(%)
SIMD 2009 Version 2 Scottish Decile				
Missing	0	(0%)	918	(13%)
1	6183	(12%)	935	(13%)
2	5594	(11%)	772	(11%)
3	5045	(10%)	670	(10%)
4	5047	(10%)	644	(9%)
5	4821	(10%)	635	(9%)
6	4788	(10%)	538	(8%)
7	4815	(10%)	560	(8%)
8	5061	(10%)	537	(9%)
9	4654	(9%)	472	(7%)
10	4371	(9%)	350	(5%)

***frequencies and percentages altered to avoid releasing identifiable data**

3.4.1.2 Description of: DHSW Courtesy Visit; DHSW – First Visit; and Dental Health Support Worker Record of Child / Parent Contact

The following datasets: DHSW Courtesy Visit, DHSW – First Visit, and the Dental Health Support Worker Record of Child / Parent Contact are historic datasets used during the early stages of Childsmile demonstration phase in the West of Scotland. Each of these datasets were superseded by the DHSW Childsmile Practice dataset with many of the variables from the earlier datasets contained within this. As only small amounts of records remained after they were to the linked to the 2014/2015 NDIP, these datasets will not be described in their entirety. This also resulted in the frequencies of some of the variables in these datasets being altered to avoid disclosing potentially identifiable data.

<u>**DHSW Courtesy Visit dataset**</u>

The DHSW Courtesy Visit dataset collected data on DHSW contacts that occurred after the family had attended their first Childsmile dental appointment. This dataset was active between the 1st July 2006 and the 31st March 2009 when it was superseded by the DHSW Childsmile Practice dataset. After linking the DHSW Courtesy Visit to the 2014/2015 NDIP, no records remained for children in either the included or excluded groups due to this form no longer being in use when the children in the 2014/2015 NDIP were born.

DHSW – First Visit Contact dataset

The DHSW – First Visit Contact dataset collected data relating to the initial contact between a family and a DHSW from the 1st of July 2006, when the Childsmile programme was launched, to 31st March 2009 where it was superseded by the DHSW Childsmile Practice Dataset. Table 3-3 describes the count of variables within the DHSW – First Visit Dataset after linkage to the 2014/2015 NDIP where only 41 and 20 records remained in the included and excluded groups respectively.

Most of the categories within the DHSW – First Visit dataset showed no differences between the included and excluded datasets suggesting there was no systematic bias between the groups. For those variables where clear differences were observed, there were only small number of records involved and it was unlikely to have a substantial impact on the results.

DHSW Record of Child / Parent Contact dataset

The DHSW Record of Child / Parent Contact dataset contained data relating to DHSW contacts with families and their children between the 1st April 2006 and the 31st March 2009. It was used when the family was to be visited by a DHSW after their initial contact. This dataset was superseded by the DHSW Childsmile Practice dataset. Table 3-4 describes the frequency of categories in each variable within the DHSW Record of Child / Parent Contact dataset. Due to the small number of records that remained after the linkage to the 2014/2015 P1 NDIP, the categories of all the variables in the dataset where the frequency was not zero were altered to <5. None of the variables in this dataset had any missing data. The small numbers and near identical rates of the categories of each variable observed across the included and excluded datasets indicated that there was likely no impact of difference nor systematic bias between the included and excluded.

Table 3-3: Frequency of categories within each variable of the DHSW – First Visit, after data linkage, by records included in and excluded from the final study cohort

Variable	Included n	(%)	Excluded n	(%)
Date of Birth				
Complete	41	(100%)	20	(100%)
Missing	0	(0%)	0	(0%)
Date of Planned Contact with a DHSW				
Complete	41	(100%)	20	(100%)
Missing	0	(0%)	0	(0%)
Date of appointment with Dental Services				
Complete	41	(100%)	20	(100%)
Missing	0	(0%)	0	(0%)
Sex				
Female	7	(17%)	8	(40%)
Male	33	(80%)	12	(60%)
Missing	1	(2%)	0	(0%)
DHSW ID				
Complete	41	(100%)	20	(100%)
Missing	0	(0%)	0	(0%)
Programme Explained				
Yes	41	(100%)	20	(100%)
Existing Dentist				
No	11	(27%)	6	(30%)
Yes	30	(73%)	14	(70%)
Childsmile Practice				
No	<5	(<12%)*	<5	(<25%)*
Yes	>36	(>88%)*	>14	(>70%)*
Missing	0	(0%)	1	(5%)
Practice Code				
Complete	40	(98%)	17	(85%)
Missing	1	(2%)	3	(15%)
Practice Not Chosen				
No	41	(100%)	20	(100%)
Do Not Want				
No	41	(100%)	>15*	(75%)*
Yes	0	(0%)	<5*	(25%)*

*frequencies and percentages altered to avoid releasing identifiable data

Table 3-4: Frequency of categories within each variable of the Record of Child / Parent Contact dataset, after data linkage, by records included in and excluded from the final study cohort

Variable	Included n	(%)	Excluded n	(%)
Date of Birth				
Complete	<5*	(100%)	<5*	(100%)
Missing	0	(0%)	0	(0%)
Date of Planned Contact with a DHSW				
Complete	<5*	(100%)	<5*	(100%)
Missing	0	(0%)	0	(0%)
Sex				
Female	0	(0%)	<5*	(100%)
Male	<5*	(100%)	0	(0%)
DHSW ID				
Complete	<5*	(100%)	<5*	(100%)
Missing	0	(0%)	0	(0%)
Result of the Appointment				
Home/Other - Yes	<5*	(100%)	<5*	(100%)
Missing	0	(0%)	0	(0%)
Dietary				
No	<5*	(100%)	<5*	(100%)
Yes	0	(0%)	0	(0%)
Toothbrushing				
No	<5*	(100%)	<5*	(100%)
Yes	0	(0%)	0	(0%)
Dental Pack Issued				
No	<5*	(100%)	<5*	(100%)
Yes	0	(0%)	0	(0%)

*frequencies and percentages altered to avoid releasing identifiable data

3.4.1.3 Description of DHSW Childsmile Practice Dataset

The DHSW Childsmile Practice dataset superseded the DHSW First Visit, the DHSW Record of Child / Parent Contact, and the DHSW Courtesy Visit databases and contains data relating to all DHSW contacts with families and their children between the 1st April 2009 and 31st December 2010. Table 3-5 describes the frequency of categories in each variable within the DHSW Childsmile Practice dataset.

The **'Date of Birth'** and **'Date of Planned Contact with a DHSW'** variables had a 100% completion rate. The **'Date of appointment with Dental Services'** was entered on 58% of the included records and 56% of the excluded records but this variable could only be completed when the **'Result of the Appointment'** was 'Appointment Kept' which was only recorded for 76% and 74% of the records respectively. Furthermore, although the DHSW could make an appointment for the child with dental services, parents could also choose to make their own dental arrangements for their child. It was also possible for the DHSW to arrange an appointment with dental services but for no date to be recorded if an appointment date had not yet been arranged. The **'Date of Visit for continued Home Support'** was only completed for <1% of the records. This was only completed if the **'Result of the Appointment'** was 'Appointment Kept'. The DHSW only offered families continued home support if their professional opinion was that the family would benefit from extra support.

The quality of completeness of the **'Sex'** variable was low in this dataset with the data missing from around half of records in both included and excluded groups.

The unique **'DHSW ID'**, the ID code of the DHSW that was due to visit the family, was 100% complete for all records. The **'Type of Contact'** that was recorded related to whether the DHSW was due to meet the child at their home, in a clinic, via phone or by another method; with 94% (included) and 95% (excluded) of contacts scheduled to take place in the child's home. The **'Result of the Appointment'** with the DHSW had four categories. The first three were: 'Appointment Kept'; 'Declined on day' which was when the DHSW makes contact with the family/child but was unable to proceed to deliver the Childsmile interventions; 'and Failed to Attend/Not Home' (which was when the DHSW attended a scheduled appointment but the family/child were not present). The fourth category was 'Other' which was any result that did not fit into the three other categories although this was only used on less than five occasions. Around three quarters of all of the scheduled appointments were 'Appointment Kept' (similar in both the included and excluded groups).

The **'Reason Given for Declining on Day'** variable recorded the reason why a DHSW was unable to proceed to deliver the Childsmile interventions after making contact with the family and child. Most appointments were kept, and those that were not were most likely to be because the family and child were not at home at the time of the appointment. Most records (~95%) from both the included and excluded datasets were missing these data. Taking these records out of consideration, the most common reason in both datasets for the declined appointment was because the family refused to engage with Childsmile (~40%).

The **'Dietary'**, **'Toothbrushing'** and **'Dental Pack Issued'** variables recorded if these DHSW Childsmile interventions were delivered at the appointment or not. The 'No' category also included those records where the appointment was not kept. For appointments that were kept, dietary advice was given on 74% (included) and 75% (excluded) of occasions, toothbrushing advice on 79% (included) and 82% (excluded) of occasions and dental packs were given to the family on 81% (included) and 82% (excluded) of the contacts.

The **'Appointment with Dental Services'** variable indicates if the DHSW had facilitated the family with a dental appointment. The 'No' category also included those records where the appointment was not kept. When considering only the kept appointments, the DHSW arranged a dental appointment for the child in 91% of the records in both groups. **'Practice Code'** was used to record the unique dental practice ID of where the DHSW had made an appointment. The 'Missing' category also included those children where the appointment was not kept and those where the DHSW was not facilitating the family with an appointment at a dental practice. When considering only those children where the DHSW was facilitating the appointment, the **'Practice Code'** was recorded on 47% (included) and 53% (excluded) of the records. The completeness of **'Continued Home Support'**, when the DHSW offers additional support to the family, also has the same caveats as **'Appointment with Dental Services'**. After considering only kept appointments, the completeness of this variable remained at below 1% for both groups.

The **'Re-contact Family Failed to Attend / Not at Home'** variable indicated whether or not the DHSW was attempting to rearrange an appointment with a family, if the prior contact had not been kept. The 'No' category included contacts where the appointment was kept so when considering only records where the **'Result of the Appointment'** category was 'Failed to Attend / Not Home', the rates of 'Yes' rose to 65% (included) and 62% (excluded). The **'Re Scheduled Appointment - Decline on Day'** variable was to record if the DHSW was to attempt to arrange another appointment with the family after the family declined to engage with Childsmile at that particular contact. The 'No' category also included contacts where the appointment was kept so when considering only records where the **'Result of the Appointment'** category was 'Declined on day', the rates of 'Yes' rose to 37% of included and 39% of excluded records.

The **'Dental Pack Delivered – Not Home'** variable recorded whether the DHSW had left a dental pack containing a toothbrush, toothpaste and oral health information at the family home if the family was not home at the time of the scheduled appointment. The same caveat and methods were applied to this variable and the 'Yes' categories rose to 13% of included and 15% of excluded records.

The **'Refused Childsmile refer to Health Visitor'** variable recorded that the DHSW was going to refer the child/family to a Heath Visitor after they had refused any further engagement with the DHSW. The 'No' category contained records where Childsmile was not refused. Considering only the records where the **'Reason Given for Declining on Day'** category was 'Refused Childsmile', the rates of 'Yes' were 6% (included) and 16% (excluded). This may be due to families from higher areas of deprivation who did not have an NDIP inspection also being less likely to engage with other NHS services.

The **'Referred to Health Visitor'** variable was used to indicate if a child was being referred to a Health Visitor for any reason other than refusing to engage with Childsmile. The **'No Further Action Required'** variable was used to indicate that the family would be making their own dental arrangements and that there was no further involvement from the DHSW required.

The percentages of categories in the DHSW Childsmile Practice dataset variables were very similar in both the included and excluded groups with no systematic bias. The **'Sex'** variable had a poor level of completeness.

Table 3-5: Frequency of categories within each variable of the DHSW Childsmile Practice Dataset, after data linkage, by records included in and excluded from the final study cohort

Variable	Included n	(%)	Excluded n	(%)
Date of Birth				
Complete	8363	(100%)	1389	(100%)
Missing	0	(0%)	0	(0%)
Date of Planned Contact with a DHSW				
Complete	8363	(100%)	1389	(100%)
Missing	0	(0%)	0	(0%)
Date of appointment with Dental Services				
Complete	4873	(58%)	778	(56%)
Missing	3490	(42%)	611	(44%)
Date of Visit for continued Home Support				
Complete	15	(<1%)	2	(<1%)
Missing	8348	(>99%)	1387	(>99%)
Sex				
Female	1828	(22%)	579	(42%)
Male	1790	(21%)	672	(48%)
Missing	4745	(57%)	138	(10%)
DHSW ID				
Complete	8363	(100%)	1389	(100%)
Missing	0	(0%)	0	(0%)
Type of Contact				
Clinic	303	(4%)	53	(4%)
Home Visit	7877	(94%)	1314	(95%)
Other	22	(<1%)	<5*	(<1%)*
Phone Call	161	(2%)	>16*	(<1%)*
Result of the Appointment				
Appointment Kept	6347	(76%)	1025	(74%)
Declined on day	488	(6%)	82	(6%)
Failed to Attend / Not Home	>1523*	(>18%)*	282	(20%)
Other	<5*	(<1%)*	0	(0%)
Reason Given for Declining on Day				
Missing	7919	(95%)	1308	(94%)
Child/family member ill	31	(<1%)	6	(<1%)
Inconvenient	126	(2%)	26	(2%)
Other	116	(1%)	18	(1%)
Refused Childsmile	171	(2%)	31	(2%)

Table 3-5 continued

Variable	Included n	(%)	Excluded n	(%)
Dietary				
No	3685	(44%)	624	(45%)
Yes	4678	(56%)	765	(55%)
Toothbrushing				
No	3325	(40%)	549	(40%)
Yes	5038	(60%)	840	(60%)
Dental Pack Issued				
No	3247	(39%)	546	(39%)
Yes	5116	(61%)	843	(61%)
Appointment with Dental Services				
No	2563	(31%)	461	(33%)
Yes	5800	(70%)	928	(67%)
Practice Code				
Complete	2741	(33%)	488	(35%)
Missing	5622	(67%)	901	(65%)
Continued Home Support				
No	8342	(>99%)	>1384*	(>99%)*
Yes	21	(<1%)	<5*	(<1%)*
Re-contact Family Failed to Attend / Not Home				
No	7365	(88%)	1211	(87%)
Yes	998	(12%)	178	(13%)
Re Scheduled Appointment - Decline on Day				
No	8184	(98%)	1357	(98%)
Yes	179	(2%)	32	(2%)
Dental Pack Delivered Not Home				
No	8188	(98%)	1350	(97%)
Yes	175	(2%)	39	(3%)
Refused Childsmile refer to Health Visitor				
No	8353	(>100%)	1384	(>100%)
Yes	10	(<1%)	5	(<1%)
Referred to Health Visitor Other				
No	8142	(97%)	1349	(97%)
Yes	221	(3%)	40	(3%)

Table 3-5 continued

Variable	Included n (%)		Excluded n (%)	
No Further Action Required				
No	7882	(94%)	1307	(94%)
Yes	481	(6%)	82	(6%)

*frequencies and percentages altered to avoid releasing identifiable data

3.4.1.4 Description of HIC DHSW Practice Interventions Dataset

The HIC DHSW Practice Interventions dataset, which superseded the DHSW Childsmile Practice dataset, collected data relating to all DHSW contacts with families and their children after the 1st December 2010. Table 3-6 describes the frequency of categories in each variable within the HIC DHSW Practice Interventions Dataset.

The **'Date of Birth'** and the **'Date of Planned Contact with a DHSW'** variables had a 100% completion rate. The **'Date of Referral to DHSW'** variable, which is the date the child was referred to a DHSW, was missing for most records. This was due to this variable being introduced after the expected time frame when most children in the 2014/2015 NDIP would have received their referral to a DHSW.

The **'Date of appointment with Dental Services'** was entered on 46% of the included records and 41% of the excluded records but this variable could only be completed when the result of the appointment was 'Success', which was only recorded for 72% and 70% of the records respectively. Furthermore, although the DHSW could make an appointment for the child with dental services, parents could also choose to make their own dental arrangements for their child. It was also possible for the DHSW to arrange an appointment with dental services but for no date to be recorded, for example if an appointment date had not yet been arranged. The **'Date of Visit for continued Home Support'** variable was only completed for 9% and 6% of the records. The DHSW only offered families continued home support if their professional opinion was that the family would benefit from extra support. Like the **'Date of appointment with Dental Services'** variable, this was only completed if the result of the appointment was 'Success'. After accounting for this, the percentage increased to 80% for both datasets.

The **'Health Board'** variable is the health board location of the DHSW's base rather than the child. Due to low values in NHS Orkney, Shetland, Western Isles and Lothian, the data for these four health boards were pooled so that these data could be released from the Safe Haven. As there was to be no further analysis by health board, this choice of grouping these four health boards together for the means of releasing the data from the Safe Haven was inconsequential.

'DHSW ID' is the unique ID of the DHSW who was due to visit the family and was complete for all records. The postcode of their work base location was mostly complete and similar for both the included (83%) and excluded records (83%).

The **'Referral By / At'** variable indicates that the source of referral for most children to a DHSW was by a Health Visitor (68% for both groups). An open text field was used to record the method of referral if 'Other' had been selected in the **'Referral By / At'** variable'. The **'Health Visitor'** variable is the name of the Health Visitor that referred the child to a DHSW. **'Health Visitor ID'** is the unique ID of the aforementioned Health Visitor and **'Health Visitor Base'** is the address of the base the Health Visitor works from. The latter two variables were introduced after the expected time frame when most children in the 2014/2015 NDIP would have been referred to a DHSW which accounts for their low completion rate. There was a difference of four percent difference in the completeness of the **'Health Visitor Base'** dataset between the included and excluded datasets. As this was a new variable that was not available for the full duration of the study, there may have been fluctuations in how this was completed across different health boards which may account for the differences observed.

The **'Statement Read'** variable indicates whether or not the DHSW explained to the family that the data related to contacts between them would be used for Childsmile monitoring and evaluation purposes. This only had to be read once so many of the 'No' and 'Missing' categories would have previously had a record that was 'Yes'.

The **'Type of Contact'** that was recorded indicated whether the DHSW was due to meet the child at their home, in a clinic, via phone or by another method. There were 63% of contacts that were a 'Home Visit' in the included dataset compared to 69% in the excluded. Families living in the most deprived areas were the most likely to not have received an NDIP inspection and therefore be in the excluded dataset, and this demographic was also the most likely to have additional home visits scheduled (Hodgins et al., 2018) and this could explain the slightly higher rates of home visits in the excluded datasets.

The **'Result of the Appointment with the DHSW'** variable had four categories. The first three are: 'Success' which is when the appointment is kept; 'Declined' which is when the DHSW makes contact with the family and child but is unable to proceed to deliver the Childsmile interventions; 'No Entry' which is when the DHSW attended a scheduled appointment, but the family/child was not present. Around three quarters of all the scheduled appointments were 'Success'. There were only 16% of contacts where the DHSW was not granted entry in the included dataset but this increased to 23% in the excluded. This was most likely due to families from more deprived areas being less likely to engage with NHS services who were also the most likely to be excluded from the study for not having an NDIP inspection.

The **'Reason Given for Declining on Day'** variable recorded the reason why a DHSW was unable to proceed to deliver the Childsmile interventions after making contact with the family and child. As most appointments were kept and those that were not were most likely to be because the family/child was not at home at the time of the appointment, most records were missing for this data (~95%). Taking these records out of consideration, the most common reason for the declined appointment was because the appointment was at an inconvenient time.

The **'Dietary'**, **'Toothbrushing'** and **'Dental Pack Issued'** variables recorded if these DHSW Childsmile interventions were delivered at the appointment. The 'No' category also included those records where the appointment was not kept. When considering only kept appointments, interventions delivered were very similar in both the included and excluded groups: **'Dietary'** advice was given on 75% (included) and 73% (excluded) of occasions, **'Toothbrushing'** advice on 78% (included) and 77% (excluded) of occasions with **'Dental Pack**(s) **Issued'** to the family on 65% (included) and 66% (excluded) of the contacts.

The **'Appointment with Dental Services'** variable indicated whether the DHSW facilitated the family with a dental appointment. The 'No' and 'Missing' categories also included those records where the appointment was not kept. When considering only the kept appointments, the DHSW arranged a dental appointment for the child in 70% and 72% of the records respectively. **'Practice Code'** was used to record the unique dental practice ID of where the DHSW had made an appointment for. The 'No' category also included those children where the appointment was not kept and those where the DHSW was not facilitating the family with an appointment at a dental practice. When considering only those children where the DHSW was facilitating the appointment, the **'Practice Code'** was recorded on 72% (included) and 75% (excluded) of the records. The completeness of the **'Continued Home Support'** variable, when the DHSW offers additional support to the family, also has the same caveats as **'Appointment with Dental Services'**. After considering only kept appointments, the completeness of this variable rose to 9% in the included dataset and 11% in the excluded dataset.

The **'Re-contact Family Failed to Attend / Not at Home'** variable indicated whether the DHSW was attempting to rearrange an appointment with a family if the prior contact had not been kept. The 'No' and 'Missing' categories included contacts where the appointment was kept so when considering only those records where the **'Result of the Appointment'** category was 'No Entry', the rates of 'Yes' rose to 77% for both included and excluded groups. The **'Re Scheduled Appointment - Decline on Day'** variable was to record if the DHSW was to attempt to arrange another appointment with the family after the family declined to engage with Childsmile at that particular contact. The 'No' and 'Missing' categories also included the contacts where the appointment was kept, so when considering only those records where the **'Result of the Appointment'** category was 'Declined on day', the rates of 'Yes' rose to 53% and 62%. The **'Dental Pack Delivered – Not Home'** variable recorded if the DHSW left a dental pack containing toothbrush, toothpaste and oral health information at the family home if the family was not home at the time of the scheduled appointment. The same caveat and methods were applied to this variable and the 'Yes' categories rose from <1% in both groups to 4% (included) and 2% (excluded). Due to the very small numbers within this variable that resulted in the categories being altered to avoid releasing identifiable data, however, it is most likely that this is the reason for the small difference in percentages observed here.

The **'Refused Childsmile refer to Health Visitor'** variable recorded that the DHSW was going to refer the child/family to a Heath Visitor after they refused any further engagement with the DHSW. The 'No' category contained records where Childsmile was not refused. Considering only records where the **'Reason Given for Declining on Day'** category was 'Refused Childsmile', the rates of 'Yes' were 25% (included) and 40% (excluded).

The **'Referred to Health Visitor'** variable was used to indicate if a child was being referred to a Health Visitor for any other reason apart from refusing to engage with Childsmile. The **'No Further Action Required'** variable was used to indicate that the family would be making their own dental arrangements and that there was no further involvement from the DHSW required. The **'Family Could Not Be Contacted'** variable indicated that after multiple attempts to contact a family/child, the DHSW and was no longer actively attempting to contact the family.

The percentages of categories in the HIC DHSW Practice Interventions dataset variables were mostly very similar in both the included and excluded columns with no systematic bias observed; differences were magnified when numbers were small and are unlikely to represent significant differences in the groups.

Table 3-6: Frequency of categories within each variable of the HIC DHSW Practice Interventions Dataset, after data linkage, by records included in and excluded from the final study cohort

	Included		Excluded	
Variable	**n**	**(%)**	**n**	**(%)**
Date of Birth				
Complete	5194	(100%)	1068	(100%)
Missing	0	(0%)	0	(0%)
Date of Referral to DHSW				
Complete	564	(11%)	162	(15%)
Missing	4630	(89%)	906	(85%)
				//
Date of Planned Contact with a DHSW				
Complete	5194	(100%)	1068	(100%)
Missing	0	(0%)	0	(0%)

Table 3-6 continued

Variable	Included n	(%)	Excluded n	(%)
Date of appointment with Dental Services				
Complete	2380	(46%)	437	(41%)
Missing	2814	(54%)	631	(59%)
Date of Visit for continued Home Support				
Complete	473	(9%)	59	(6%)
Missing	4721	(91%)	1009	(95%)
Sex				
Female	2514	(48%)	474	(44%)
Male	2678	(52%)	594	(56%)
Missing	2	(<1%)	0	(0%)
Health Board				
NHS Ayrshire & Arran	484	(9%)	119	(11%)
NHS Borders	173	(3%)	29	(3%)
NHS Dumfries	303	(6%)	48	(4%)
NHS Fife	357	(7%)	71	(7%)
NHS Forth Valley	43	(1%)	5	(0%)
NHS Greater Glasgow & Clyde	1820	(35%)	405	(38%)
NHS Grampian	124	(2%)	28	(3%)
NHS Highland	891	(17%)	176	(16%)
NHS Lanarkshire	676	(13%)	145	(14%)
NHS Tayside	213	(4%)	26	(2%)
NHS Orkney, Shetland, Western Isles & Lothian**	110	(2%)	16	(1%)
DHSW ID				
Complete	5194	(100%)	1068	(100%)
Missing	0	(0%)	0	(0%)
DHSW Postcode				
Complete	4305	(83%)	890	(83%)
Missing	889	(17%)	178	(17%)
Referral By / At				
Clinic	267	(5%)	37	(3%)
Dentist	21	(<1%)	9	(<1%)
Health Visitor	3554	(68%)	729	(68%)
Other	379	(7%)	79	(7%)
Self	6	(<1%)	0	(0%)
Missing	967	(19%)	214	(20%)
Referral Other				
Complete	396	(8%)	81	(8%)
Missing	4798	(92%)	987	(92%)

Table 3-6 continued

Variable	Included n	(%)	Excluded n	(%)
Health Visitor				
Complete	3820	(71%)	786	(74%)
Missing	1551	(29%)	282	(26%)
Health Visitor ID				
Complete	147	(3%)	45	(4%)
Missing	5047	(97%)	1023	(96%)
Health Visitor Base				
Complete	289	(6%)	103	(10%)
Missing	4905	(94%)	965	(90%)
Statement Read				
No	988	(19%)	225	(21%)
Yes	2877	(55%)	597	(56%)
Missing	1329	(26%)	246	(23%)
Type of Contact				
Clinic	502	(10%)	85	(8%)
Home Visit	3286	(63%)	735	(69%)
Other	250	(5%)	53	(5%)
Telephone	865	(17%)	169	(16%)
Missing	291	(6%)	26	(2%)
Result of the Appointment				
Declined	296	(6%)	55	(5%)
No Entry	848	(16%)	242	(23%)
Success	3757	(72%)	745	(70%)
Missing	293	(6%)	26	(2%)
Reason Given for Declining on Day				
Missing	4895	(94%)	26	(95%)
Child/family member ill	37	(<1%)	5	(<1%)
Inconvenient	101	(2%)	21	(2%)
Other	82	(2%)	15	(1%)
Refused Childsmile	79	(2%)	15	(1%)
Dietary				
No	2358	(45%)	522	(49%)
Yes	2832	(55%)	546	(51%)
Missing	4	(<1%)	0	(0%)
Toothbrushing				
No	2266	(44%)	493	(46%)
Yes	2924	(56%)	575	(54%)
Missing	4	(<1%)	0	(0%)

Table 3-6 continued

Variable	Included n	(%)	Excluded n	(%)
Dental Pack Issued				
No	2766	(53%)	573	(54%)
Yes	2424	(47%)	495	(46%)
Missing	4	(<1%)	0	(0%)
Appointment with Dental Services				
No	2566	(49%)	534	(50%)
Yes	2624	(51%)	534	(50%)
Missing	4	(<1%)	0	(0%)
Practice Code				
Complete	1882	(36%)	401	(38%)
Missing	3312	(64%)	667	(63%)
Continued Home Support				
No	4837	(93%)	985	(92%)
Yes	353	(7%)	83	(8%)
Missing	4	(<1%)	0	(0%)
Re-contact Family Failed to Attend / Not Home				
No	4540	(87%)	882	(83%)
Yes	650	(13%)	186	(17%)
Missing	4	(<1%)	0	(0%)
Re Scheduled Appointment - Decline on Day				
No	5031	(97%)	1034	(97%)
Yes	159	(3%)	34	(3%)
Missing	4	(<1%)	0	(0%)
Dental Pack Delivered Not Home				
No	2178	(42%)	>389*	(>36%)*
Yes	37	(<1%)	<5*	(<1%)*
Missing	2979	(57%)	665	(62%)
Refused Childsmile refer to Health Visitor				
No	5166	(99%)	1062	(99%)
Yes	20	(<1%)	6	(<1%)
Missing	8	(<1%)	0	(0%)
Referred to Health Visitor				
No	5031	(97%)	1034	(97%)
Yes	159	(3%)	34	(3%)
Missing	4	(<1%)	0	(0%)
No Further Action Required				
No	4270	(82%)	912	(85%)
Yes	916	(18%)	156	(15%)
Missing	8	(<1%)	0	(0%)
Family Could not be Contacted				
No	4776	(92%)	1017	(95%)
Yes	291	(6%)	26	(2%)
Missing	127	(2%)	25	(2%)

*frequencies and percentages altered to avoid releasing identifiable data
**categories pooled to avoid releasing identifiable data

3.4.1.5 Description of Toothbrushing Consent Dataset

Toothbrushing Consent were the data relating to a child's consent onto the supervised toothbrushing element of Childsmile and included data that were collected between July 2006 and March 2015. Table 3-7 describes the frequency of categories in each variable within the Toothbrushing Consent Dataset. It was possible for children to have more than one consent i.e. a consent in nursery and then again in primary school.

The **'Date of Birth'** and the **'Consent Date'** (the date the child's parent or carer completed the consent form) variables had a 100% completion rate. **'Opt-out Date'**, the data the child was opted out of the supervised toothbrushing programme, was missing for over 99% of records in both the included and excluded datasets i.e. less than 1% of children were opted out of the supervised toothbrushing programme.

The **'Sex'** variable had a high completion rate with only 1% of records not having the child's sex recorded. Similar rates of sexes were observed across both the included and excluded datasets.

The **'Opt-out'** variable reports if consent was subsequently removed for a child to participate in the toothbrushing programme. After discussion with HIC, it was identified that the children in the 'Missing' category had not opted out of toothbrushing and therefore a 'Missing' value was the same as a 'No'(i.e. the children had remained consented). When both these categories are pooled together, the percentage of children that did not opt-out of toothbrushing was above 99% for both included and excluded groups.

Multiple versions of the consent form were used, and this was recorded in the **'Consent Version'** dataset. The version of the consent form used was recorded for 100% of the records.

The **'Toothbrushing Consent Result'** variable indicated if the child had been consented onto the toothbrushing programme or not with over 99% of children in both datasets being positively consented onto the toothbrushing programme.

The **'Health Information'** variable indicated that there had been a change in the medical history of the child and the **'Contact for Update'** variable indicated that because of this change in health status, the family had to be contacted. After discussion with HIC, it was established that the ‘No’, ‘Incomplete’ and ‘Missing’ categories were in fact all ‘No’. Similar percentages for both these variables were observed across both datasets. The **‘Parental Responsibility’** variable indicated that the parent or carer of the child had signed the consent form which was recorded on over 99% of occasions in both datasets.

The percentages of categories within the Toothbrushing Consent dataset variables were very similar in both the included and excluded groups with no systematic bias observed.

Table 3-7 Frequency of categories within each variable of the Toothbrushing Consent Dataset, after data linkage, by records included in and excluded from the final study cohort

Variable	Included Frequency	(%)	Excluded Frequency	(%)
Date of Birth				
Complete	70086	(>99%)	10164	(100%)
Missing	2	(<1%)	0	(0%)
Opt-out Date				
Complete	113	(<1%)	27	(<1%)
Missing	69975	(>99%)	10131	(>99%)
Consent Date				
Complete	70088	(100%)	10164	(100%)
Missing	0	(0%)	0	(0%)
Sex				
Female	34258	(49%)	4849	(48%)
Male	35806	(51%)	5312	(52%)
Missing	24	(<1%)	3	(<1%)
Opt-out				
No	14578	(21%)	2476	(24%)
Yes	111	(<1%)	27	(<1%)
Missing	55399	(79%)	7661	(75%)
Consent Version				
Complete	70088	(100%)	10164	(100%)
Toothbrushing Consent Result				
No	490	(<1%)	110	(1%)
Yes	69426	(>99%)	10026	(99%)
Missing	172	(<1%)	28	(<1%)

Table 3-7 continued

Variable	Included n	(%)	Excluded n	(%)
Contact for Update				
No	273	(<1%)	29	(<1%)
Yes	4226	(6%)	508	(5%)
Incomplete	146	(<1%)	26	(<1%)
Missing	65443	(93%)	9601	(94%)
Parental Responsibility				
No	160	(<1%)	28	(<1%)
Yes	69542	(>99%)	10084	(>99%)
Incomplete	382	(<1%)	50	(<1%)
Missing	4	(<1%)	2	(<1%)
Health Information				
No	92	(<1%)	12	(<1%)
Yes	4435	(6%)	528	(5%)
Incomplete	118	(<1%)	23	(<1%)
Missing	65443	(93%)	9601	(94%)

3.4.1.6 Description of Fluoride Varnish Visit Dataset

The Fluoride Varnish Visit data related to the application of Fluoride Varnish to children as part of the Childsmile Nursery and School Programme with data collected from July 2006 onwards. Table 3-8 describes the frequency of categories in each variable within the Toothbrushing Consent Data.

The **'Date of Birth'** variable was complete for 100% of the records. The **'Opt-out Date'** variable was the date a child's parent or carer opted them out of the fluoride varnish programme after having previously given consent. Less than 1% of children opted out across both the included and excluded datasets. The **'Visit Date'** variable, which is the date that the dental team visited the nursery or school to apply the fluoride varnish, had a 100% completion rate.

The **'Sex'** of the child had a very high completion rate with similar rates of sexes in both datasets.

The **'Opt-out'** variable indicated that the child's parent or carer had withdrawn their consent for the child to be involved in the fluoride varnish programme after having previously given consent. After discussion with HIC, it was established that records with a 'Missing' value had not opted out and therefore could be pooled together with the ‘No’ category. After pooling both of these categories, more than 99% of children in both datasets did not opt-out of the fluoride varnish programme.

The **‘Varnish’** variable indicated whether a fluoride varnish was applied to the child on that visit date. There was a higher rate of children who were given fluoride varnish in the included dataset (89%) compared to the excluded dataset (83%). This was to be expected as the excluded group already contained children that were absent from school on the date of the NDIP inspection, particularly as they were more likely to be from a deprived area (Scottish Government, 2018a), and were less likely to be in nursery / school on the fluoride varnish date.

The **‘Varnish Applied By’** variable indicated who the person was that applied the fluoride varnish to the child’s teeth and the **‘Varnish Applied By Postcode’** indicated the base that this person worked from. The missing category in both of these variables also included those children who did not have a fluoride varnish applied on the visit date. After adjusting for this, the **‘Varnish Applied By’** variable had a completion rate of 98% in both datasets. For the ‘**Varnish Applied By Postcode’** variable, the completion rate rose to 44% and 52% respectively. Although there is a measured difference between both of these percentages, this variable was newly added to the dataset during 2015 so fluctuations in the quality and completeness of this variable may explain the differences observed.

The **‘Batch’** variable is the batch code of the fluoride varnish applied or to be applied to the children’s teeth and the **‘Batch Expiry’** variable is the date by which that batch of fluoride varnish had to be applied by. The **‘Varnish Type’** variable recorded the type or brand of fluoride vanish applied to the children’s teeth. Again the ‘Missing’ category included children that did not have a fluoride varnish. When accounting for this, the variable completeness rate rose from 18% (included) and 17% (excluded) to 21% for both datasets. Although there was a low completion rate of this variable, it should be noted that the same varnish type, Duraphat, was used for all applications.

The **‘Quadrant 5’** variable indicated whether fluoride varnish was applied to the upper right quadrant of a child’s mouth and the **‘Quadrant 6’** variable indicated whether it had been applied to the upper left quadrant of a child’s mouth. Similarly, the **‘Quadrant 7’** variable related to the lower left quadrant and the

'Quadrant 8' variable to the lower right quadrant of a child's mouth. Completion rates of these variables were poor but similar completion rates across all four variables were observed in both the included and excluded groups.

The **'Referral for Caries'** variable was for referring to a dentist when signs of potential caries were observed; the **'Referral Abscesses'** variable for having an abscess and **'Referral Other'** for any other reason. In each of these variables, there were similar referral rates across both the included and excluded datasets. This provides further evidence that there was no bias with regards to the oral health of those children in either the included or excluded groups.

The **'Reason Varnish Not Applied'** variable captured the reason why a child did not have fluoride varnish applied on a particular visit. The 'Missing' category was the default and included those children that received a fluoride varnish application. The most common reason for a child not receiving a fluoride varnish was that they were absent from nursery or school on the day the varnish was due to be applied. The rate of absence was similar in both the included and excluded groups.

The percentages of categories within the Fluoride Varnish dataset variables were very similar in both the included and excluded groups with no systematic bias observed.

Table 3-8: Frequency of categories within each variable of the Fluoride Varnish Dataset, after data linkage, by records included in and excluded from the final study cohort

Variable	Included Frequency	Included (%)	Excluded Frequency	Excluded (%)
Date of Birth				
Complete	114246	(100%)	15390	(100%)
Missing	0	(0%)	0	(0%)
Opt-out Date				
Complete	87	(<1%)	10	(<1%)
Missing	114159	(>99%)	15380	(>99%)
Visit Date				
Complete	114246	(100%)	15390	(100%)
Missing	0	(0%)	0	(0%)
Sex				
Female	56241	(49%)	7424	(48%)
Male	57977	(51%)	7965	(52%)
Missing	28	(<1%)	1	(<1%)
Opt-out				
No	23621	(21%)	3554	(23%)
Yes	87	(<1%)	10	(<1%)
Missing	90538	(79%)	11826	(77%)
Varnish				
No	13133	(12%)	2577	(17%)
Yes	101113	(89%)	12813	(83%)
Varnish Applied By				
Complete	99104	(87%)	12512	(81%)
Missing	15142	(13%)	2878	(19%)
Varnish Applied By Postcode				
Complete	44505	(39%)	6669	(43%)
Missing	69741	(61%)	8721	(57%)
Batch				
Complete	101333	(89%)	12849	(83%)
Missing	12913	(11%)	2541	(17%)
Batch Expiry				
Complete	101322	(89%)	12848	(83%)
Missing	12924	(11%)	2542	(17%)

Table 3-8 continued

Variable	Included n	(%)	Excluded n	(%)
Varnish Type				
Complete	20972	(18%)	2654	(17%)
Missing	93274	(82%)	12736	(83%)
Quadrant 5				
No	109982	(96%)	14692	(95%)
Yes	4264	(4%)	698	(5%)
Quadrant 6				
No	109999	(96%)	14719	(96%)
Yes	4247	(4%)	672	(4%)
Quadrant 7				
No	109170	(96%)	14609	(95%)
Yes	5076	(4%)	781	(5%)
Quadrant 8				
No	109200	(96%)	14594	(95%)
Yes	5046	(4%)	796	(5%)
Referral Caries				
No	105247	(92%)	14007	(91%)
Yes	8986	(8%)	1381	(9%)
Missing	13	(<1%)	2	(<1%)
Referral Abscess				
No	114120	(>99%)	15378	(>99%)
Yes	126	(<1%)	12	(<1%)
Referral Other				
No	114167	(>99%)	15384	(>99%)
Yes	79	(<1%)	6	(<1%)
Reason Varnish Not Applied				
Absent	7201	(6%)	1325	(7%)
Left	577	(<1%)	235	(2%)
Other	1177	(1%)	201	(1%)
Sore mouth	121	(<1%)	17	(<1%)
Unwell	53	(<1%)	10	(<1%)
Unwilling	3950	(3%)	781	(5%)
Missing	101167	(89%)	12821	(83%)

3.4.1.7 Description of MIDAS Treatments Dataset

The Management Information and Dental Accounting System (MIDAS), is the database which records all payments to dental practitioners for treatments delivered via NHS Scotland including Childsmile interventions which was first recorded on MIDAS on the 1st January 2009. Table 3-9 describes the frequency of categories in each variable within the MIDAS dataset.

The **'Date of Birth'** variable, the **'Start Date of Treatment'** variable which is the date a child began a specific course of treatment, and the **'Stop Date of Treatment'** which is the date a child ended a specific course of treatment all had a 100% completion rate.

The **'Sex'** of the children was the same in both the included and excluded datasets.

The **'Location Number'** which is a unique ID for each dental practice, and the **'Dental Practice Postcode'** were both 100% completed.

The **'Dentist Fee Value'** variable indicated how much a dentist was being paid for a particular item or course of treatment and was 100% complete. The **'Number of Courses Paid'** variable indicated how many times a particular treatment was being claimed for. There was little difference between the included group where 62% were '0' and 38% were '1' and the excluded group where 63% were '0' and >37% were '1'.

The **'Special Needs'** variable indicated if the child had any special needs such as a learning difficulty or a physical disability. More than 99% of children did not have **'Special Needs'** and the percentages were the same for both datasets.

The **'Feecode'** variable indicted the type of treatment that was given to the child and was 100% complete for both datasets. Due to the large number of treatments available, it was not practical to list them all.

The percentages of categories within the MIDAS dataset variables were very similar in both the included and excluded columns with no systematic bias observed.

Table 3-9: Frequency of categories within each variable of the MIDAS Treatments Dataset, after data linkage, by records included in and excluded from the final study cohort

Variable	Included n	(%)	Excluded n	(%)
Date of Birth				
Complete	427605	(100%)	58229	(100%)
Missing	0	(0%)	0	(0%)
Start Date of Treatment				
Complete	427605	(100%)	58229	(100%)
Missing	0	(0%)	0	(0%)
Stop Date of Treatment				
Complete	427605	(100%)	58229	(100%)
Missing	0	(0%)	0	(0%)
Sex				
Female	215986	(51%)	29573	(51%)
Male	211619	(49%)	28656	(49%)
Location Number				
Complete	427605	(100%)	58229	(100%)
Missing	0	(0%)	0	(0%)
Dental Practice Postcode				
Complete	427605	(100%)	58229	(100%)
Missing	0	(0%)	0	(0%)
Dentist Fee Value				
Complete	427605	(100%)	58229	(100%)
Missing	0	(0%)	0	(0%)
Number of Courses Paid				
0	265282	(62%)	36936	(63%)
1	162315	(38%)	>21287*	(>37%)*
2	8	(<1%)	<5*	(<1%)*
Amount Claimed				
Complete	427605	(100%)	58229	(100%)
Missing	0	(0%)	0	(0%)

Table 3-9 continued

Variable	Included n	(%)	Excluded n	(%)
Special Needs				
No	425245	(<99%)	57824	(<99%)
Yes	463	(<1%)	112	(<1%)
Missing	1897	(<1%)	293	(<1%)
Fee Code				
Complete	427605	(100%)	58229	(100%)
Missing	0	(0%)	0	(0%)

***frequencies and percentages altered to avoid releasing identifiable data**

3.4.1.8 Description of the Childsmile Dental Practice Dataset

The Childsmile Dental Practice dataset collated data from Childsmile interventions delivered in the dental practice from multiple sources and included data that may already have been captured in the MIDAS dataset. Table 3-10 describes the frequency of categories in each variable within the Childsmile Dental Practice dataset. As most of the variables are the same as those described for the MIDAS dataset in Section 3.4.1.7 no further description of the variables will be undertaken. The data in table 3-10 has been reviewed and the percentages of categories within the Childsmile Dental Practice dataset variables were very similar in both the included and excluded groups with no systematic bias observed.

Table 3-10: Frequency of categories within each variable of the Childsmile Dental Practice Dataset, after data linkage, by records included in and excluded from the final study cohort

Variable	Included n	(%)	Excluded N	(%)
Date of Birth				
Complete	145850	(100%)	20978	(100%)
Missing	0	(0%)	0	(0%)
Start Date of Treatment				
Complete	145850	(100%)	20978	(100%)
Missing	0	(0%)	0	(0%)
Stop Date of Treatment				
Complete	144206	(99%)	20655	(99%)
Missing	1644	(1%)	323	(1%)
Sex				
Female	72844	(50%)	10683	(51%)
Male	73006	(50%)	10295	(49%)

Table 3-10 continued

Complete	145041	(>99%)	20787	(>99%)
Missing	809	(<1%)	191	(<1%)
Childsmile Practice Code				
Complete	143176	(98%)	20487	(98%)
Missing	2674	(2%)	491	(2%)
Item Description				
Annual Fee	18478	(13%)	2497	(12%)
Application of Fluoride Varnish	23857	(16%)	3396	(16%)
Dietary Advice	45226	(31%)	6424	(31%)
Enrolment	12377	(9%)	2095	(10%)
Failed to Attend	1654	(1%)	331	(2%)
Toothbrushing Advice	44258	(30%)	6235	(30%)
Count				
Complete	144779	(>99%)	20748	(99%)
Missing	1071	(<1%)	230	(1%)
Source				
CDSCHI	1071	(<1%)	230	(1%)
GP17CHI	>144774*	(>99%)*	20742	(99%)
PINKGDS	<5*	(<1%)*	6	(<1%)
Type				
GDS	128894	(88%)	18548	(88%)
SS	16953	(12%)	2430	(12%)
Missing	3	(<1%)	0	(0%)

*frequencies and percentages altered to avoid releasing identifiable data

3.5 Outcome Variable Definition

The primary outcome for this study was presence of obvious caries. A binary outcome variable ‘Children with Obvious Caries Experience’ i.e. ‘Caries Experience’ was created to measure the impact of each of the Childsmile interventions on caries experience of five-year-old children in Scotland.

Using a method previously developed by Brewster et al. (2013), children with a ‘True’ recorded within the 2014/2015 Primary One Basic National Dental Inspection Programme (NDIP) for at least one of the routinely collected variables in Box Two, were defined as having ‘Caries Experience’.

Box Two: National Dental Inspection Variables indicating obvious caries experience

- 'A1 – Abscesses or Infection'.
- 'A2 – Gross Caries'.
- 'A3 – Obviously carious Permanent Tooth'.
- 'B1 - Obviously carious Primary Tooth'.
- 'B2 – Possibly carious Primary Tooth'.
- 'B3 – Missing Primary Molar'.
- 'B4 – Evidence of Restorations'.

When only a 'True' for either B5 – Poor Oral Hygiene' or 'C – No obvious caries experience' was recorded, then children were defined as having 'No Obvious Caries Experience' i.e. 'No Caries Experience'. Of the 50,379 in the cohort, 30% (n = 15,032) had Caries Experience and 70% (n = 35,347) had No Caries Experience'. Although there was not a Detailed NDIP inspection in 2014/2015, the 2013/2014 and 2015/2016 Detailed NDIP results indicated that respectively, there was 32% and 31% of children with Caries Experience, slightly higher than the 30% in the study cohort.

3.6 Cleaning of Intervention Datasets and Assembly of Intervention Variables

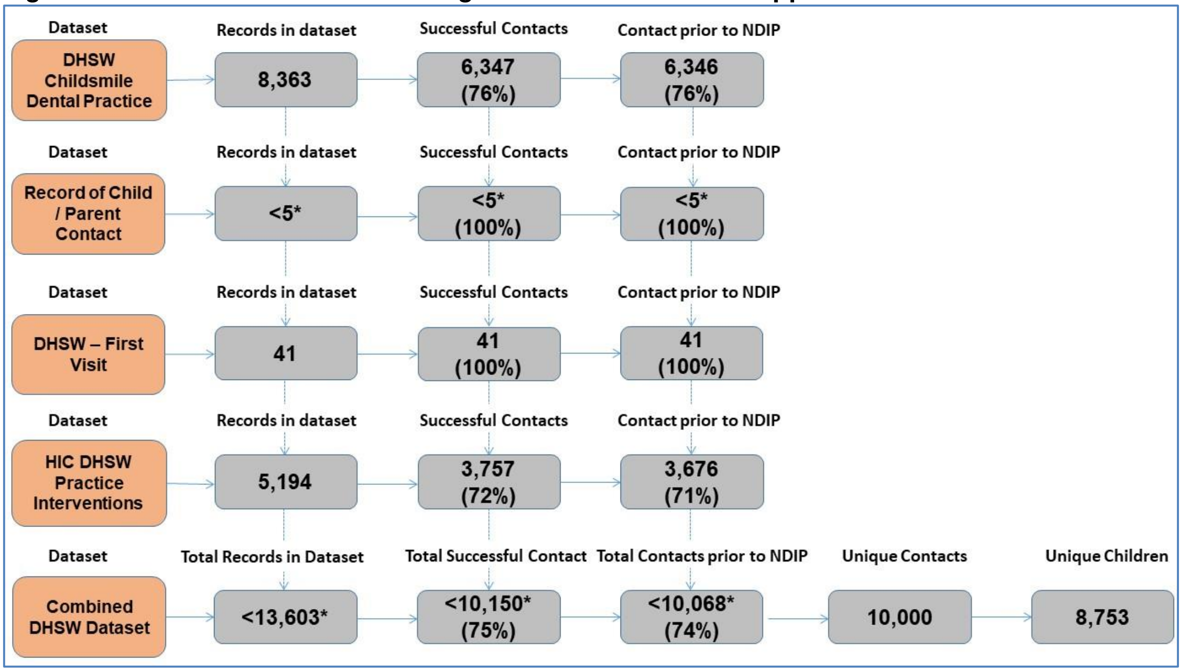
The following section describes the assembly of variables that were used to describe a child 'dosage' of each of the four Childsmile interventions – Dental Health Support Worker (DHSW) contacts, Childsmile dental practice contacts, and supervised toothbrushing and fluoride varnish applications in nurseries and schools.

3.6.1 Cleaning of Dental Health Support Worker Datasets and Assembly of 'Dental Health Support Worker Contacts' Variable

The DHSW component of Childsmile consisted of three main interventions which were providing dietary and toothbrushing advice along with a dental pack containing a toothbrush and fluoride toothpaste to the family. The intensity of each intervention varied depending on the oral health needs of the child and family as assessed by the DHSW. It is not possible with the data available to measure the intensity of each of the individual interventions at each individual contact. Therefore, a contact between the DHSW and a family, regardless of what was delivered at it, defined as a 'DHSW Contact' was chosen as the higher-level dose intervention for the subsequent analyses of this component.

To generate a DHSW Contacts variable, firstly each of the four Dental Health Support Worker (DHSW) datasets: DHSW Childsmile Dental Practice; DHSW Record of Child / Parent Contact; DHSW – First Visit and HIC DHSW Practice Interventions were cleaned to only keep those records where there were successful contacts i.e. when the DHSW had met with the family and delivered a Childsmile intervention (Figure 3-2). For the DHSW Childsmile Dental Practice dataset, records where the Result of the Appointment was 'Appointment Kept' were defined as a successful contact (n = 6,346). For the DHSW Record of Child / Parent Contact dataset, records where the Result of the Appointment was 'Home / Other – Yes' were defined as a successful contact (<5). All records within the DHSW – First Visit dataset were defined as successful contacts as this form was only completed when the DHSW had successfully made contact with a family (n = 41). For the HIC DHSW Practice Intervention dataset, records where the Result of the Appointment was 'Success' were defined as a successful contact. Records were then only kept for those contacts that were prior to the child's inspection date (n = <10,068). As it was feasible that a contact may have been recorded twice, either within the same dataset or across differing datasets, only one record per child per day was kept (n = 10,000). Overall, of the 50,379 children in the study, 8,753 (17%) children had at least one DHSW contact (Figure 3-2).

Figure 3-2: Flow chart of the cleaning of the Dental Health Support Worker Datasets



***frequencies and percentages altered to avoid releasing identifiable data; DHSW – Dental Health Support Worker**

Children who had a DHSW record in any of the datasets regardless of whether the contact was successful were defined as 'Targeted' (n = 9,732, 19%) and those that did not have a DHSW record as 'Not Targeted' (n = 40,647, 81%). The frequency of DHSW contacts for targeted children was counted (Table 3-11). The majority (80%) of targeted children (n = 7816) only had one contact with a DHSW. Due to the low frequencies for children with six contacts and beyond, these were tabulated into '6 plus contacts' to avoid releasing identifiable data (Table 3-11).

When a DHSW visited a family, they would only have subsequent contacts if the child was identified as requiring additional support, otherwise the child would be referred directly from the DHSW to a dental practice after the initial contact. Therefore, for the 'DHSW Contacts' variable, children with two or more contacts were tabulated into a single '2 plus contacts' variable indicating that these children were those identified as requiring additional DHSW support. A 'Not Targeted' level was added to the 'DHSW Contacts' variable so that every child in the study had a value in the 'DHSW Contacts' variable (Table 3-12).

Table 3-11: Dental Health Support Worker Contacts for targeted Children

Dental Health Support Worker Contacts	n	(%)
0 contact	979	(10%)
1 contact	7,816	(80%)
2 contact	754	(8%)
3 contact	118	(1%)
4 contact	36	(<1%)
5 contact	13	(<1%)
6 plus contacts	16	(<1%)
Total Unique Children Targeted	9,732	

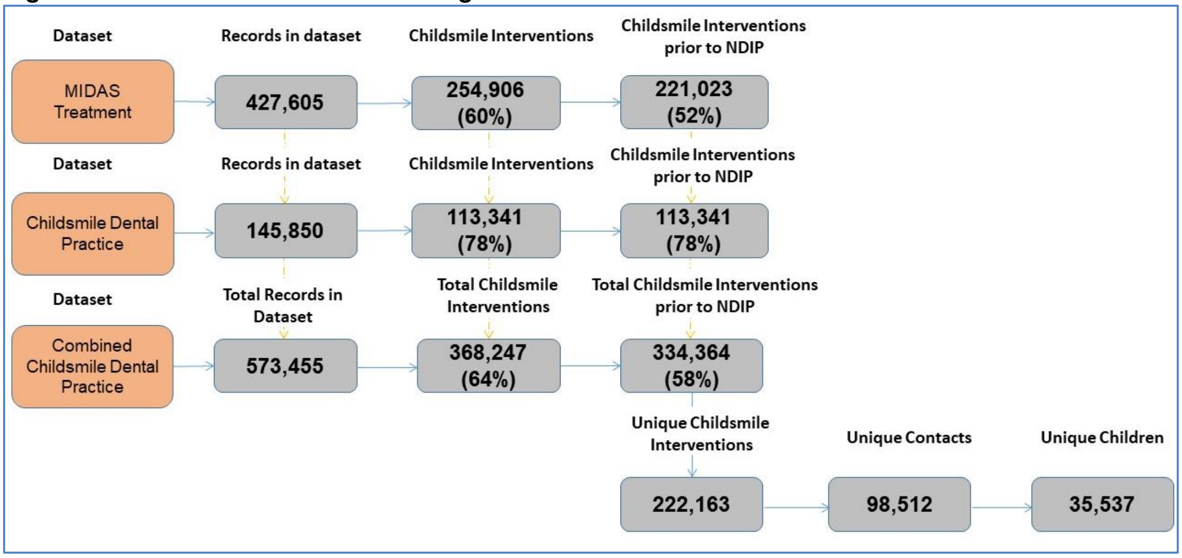
Table 3-12: Frequency of categories within the 'Dental Health Support Worker Contacts' Variable

Dental Health Support Worker Contacts	n	(%)
Not Targeted	40,647	(81%)
0 contact	979	(2%)
1 contact	7,816	(15%)
2 plus contacts	937	(2%)
Total Unique Children	50,379	

3.6.2 Cleaning of Dental Practice Datasets and Assembly of 'Childsmile Dental Practice Contacts' Variable

To generate a Childsmile Dental Practice Contacts variable, firstly each of the two Childsmile Dental Practice datasets, MIDAS Treatments and Childsmile Dental Practice datasets, were cleaned so that only those records where a Childsmile intervention was recorded remained i.e. the child visited a dental practice and was provided with a Childsmile Intervention by a member of the dental team (Figure 3-3). For the MIDAS Treatment dataset, there were 254,906 (60%) of Childsmile Interventions recorded. For the Childsmile Dental Practice dataset, there were 113,341(78%) Childsmile interventions recorded. Records were then only kept for those interventions that were prior to the child's inspection date (n = 334,364). As it was feasible that an intervention may have been recorded twice, either within the same dataset or across differing datasets, only one instance of each intervention per child per date was kept (n = 222,163). This represented 98,512 unique contacts (a child may have received more than one intervention at a single contact) and 35,537 unique children (71% of the children in the study).

Figure 3-3: Flow chart of the cleaning of the Childsmile Dental Practice Datasets



The frequency of Childsmile Dental Practice for each child in the study was counted (Table 3-13). Due to the low frequencies for children with ten contacts and beyond, these were tabulated into '10 plus contacts' for Table 3-13 to avoid releasing identifiable data. A '0 Childsmile contacts' level was added to the 'Childsmile Dental Practice Contacts' variable so that every child in the study had a value in the 'Childsmile Dental Practice Contacts' variable regardless of whether or not they had a Childsmile contact at a dental practice.

Table 3-13: Frequency of categories within the 'Childsmile Dental Practice Contacts' Variable

Childsmile Dental Practice Contacts	n	(%)
0 Childsmile contacts	14,842	(29%)
1 contact	10,653	(21%)
2 contact	8,265	(16%)
3 contact	6,179	(12%)
4 contact	4,529	(9%)
5 contact	3,063	(6%)
6 contact	1,577	(3%)
7 contact	668	(1%)
8 contact	345	(1%)
9 contact	161	(<1%)
10 plus contacts	97	(<1%)
Total Unique Children	50,379	

3.6.2.1 Assembly of 'Dental Practice Fluoride Varnish Applications' Variable

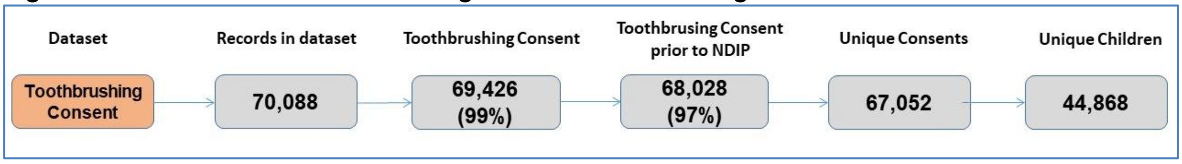
A variable, 'Dental Practice Fluoride Varnish Applications' that counted the number of fluoride varnish applications each child received in a dental practice setting was created. A cross tabulation of the frequency of fluoride varnish applications within the dental practice by the number of Childsmile Dental Practice Contacts was conducted (Table 3-14). Children who received a fluoride varnish application at every Childsmile Dental Practice Contact are highlighted in grey. To avoid releasing identifiable data, the frequencies for 6 to 7 contacts were pulled into a single level as were 8 plus contacts. For one to four contacts, the largest portion of children received a fluoride varnish at every visit. The proportion of children receiving a fluoride varnish at every contact reduced as the number of contacts increased.

Whereas children may not necessarily receive a fluoride varnish application at every Childsmile Dental Practice Contact, the programme guidelines state that children should be receiving both dietary and toothbrushing advice (collectively referred to as ‘oral health advice’) at every contact. Therefore, no additional variable was created for the oral health advice intervention as it was assumed this intervention was being delivered at every Childsmile Dental Practice Contact.

3.6.3 Cleaning of Toothbrushing Consent Dataset and Assembly of ‘Time Toothbrushing’ Variable

A ‘Time Toothbrushing’ variable was created to describe the number of years the child participated in the supervised toothbrushing programme. Firstly, the Toothbrushing Consent database was cleaned to only keep those records that were for a positive consent (n = 67,052, 99%) for a child to participate in the supervised toothbrushing programme in nurseries and schools (Figure 3-4). Records were then only kept for those consents that were prior to the child’s dental inspection date (n = 68,028). Children may have been attending more than one nursery or school, so it was possible a child may have had more than one consent. Where there was more than one consent, the earliest consent date was selected so that there was only one record per child. This represented 44,868 (89%) unique children in the study.

Figure 3-4: Flow chart of the cleaning of the Toothbrushing Consent Dataset



The time between the first date of consent and the child’s NDIP inspection date was calculated and tabulated into one-year categories. The majority (52%) of children with consent to toothbrushing (n = 23,136) had received between one and two years toothbrushing prior to their NDIP inspection.

Table 3-14: Cross Tabulation of the Frequency of 'Dental Practice Fluoride Varnish Applications' by number of Childsmile Dental Practice Contacts

	Dental Practice Fluoride Varnish Applications								
Childsmile Dental Practice Contacts	**0 n (%)**	**1 n (%)**	**2 n (%)**	**3 n (%)**	**4 n (%)**	**5 n (%)**	**6-7 n (%)**	**8 plus n (%)**	**0 Childsmile contacts n (%)**
0 Childsmile contacts	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	14,842 (100%)
1 contact	4,659 (44%)	**5,994 (56%)**	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
2 contact	1,998 (24%)	2,661 (32%)	**3,606 (44%)**	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
3 contact	964 (16%)	1,254 (20%)	1,802 (29%)	**2,159 (35%)**	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
4 contact	440 (10%)	600 (13%)	915 (20%)	1,261 (28%)	**1,313 (29%)**	0 (0%)	0 (0%)	0 (0%)	0 (0%)
5 contact	187 (6%)	279 (9%)	434 (14%)	588 (19%)	826 (27%)	**749 (24%)**	0 (0%)	0 (0%)	0 (0%)
6-7 contacts	134 (6%)	138 (6%)	263 (12%)	372 (17%)	509 (23%)	488 (22%)	**341 (16%)**	0 (0%)	0 (0%)
8 plus contacts	15 (2%)	22 (4%)	69 (11%)	90 (15%)	129 (21%)	168 (28%)	104 (17%)	**6 (1%)**	0 (0%)
Total	8,397 (17%)	10,948 (22%)	7,089 (14%)	4,470 (9%)	2,777 (6%)	1,405 (3%)	455 (<1%)	6 (<1%)	14,842 (29%)

Highlighted cells indicate children receiving a fluoride varnish contact at every Childsmile Dental Practice Contact

Table 3-15: Time Consented to Nursery and School Toothbrushing Programme

Time Consented	n	(%)
Up to 1 year	3,565	(8%)
1 to 2 years	12,579	(28%)
2 to 3 years	23,136	(52%)
3 to 4 years	3,827	(9%)
5 plus years	1,761	(4%)
Total Unique Children	44,868	

Children would typically only start toothbrushing at the age of three with the NDIP inspection occurring when the child is aged four to six years of age. Therefore, although a child may have three or more years of consent, due to consent being granted in advance i.e. when they first registered at a nursery, it was unlikely that that they would have been toothbrushing for this amount of time (although some nurseries allow children to participate in the supervised toothbrushing component from the age of two, unpublished data suggests that it is very low). Therefore, for the 'Time Toothbrushing' variable, all consents that were more than two years prior to the date of the NDIP inspection were tabulated into a '>2 years' category (Table 3-16). Children with an NDIP inspection that had not been consented to toothbrushing were assigned to a '0 (no consent)' category. The majority of children in the study (n = 28,724) had been toothbrushing for more than two years.

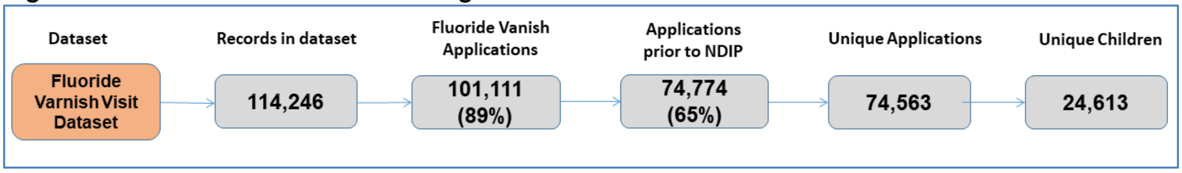
Table 3-16: Frequency of categories within the 'Time Toothbrushing' Variable

Time Toothbrushing	n	(%)
0 (no consent)	5,511	(11%)
Up to 1 year	3,565	(7%)
1 to 2 years	12,579	(25%)
>2 years	28,724	(57%)
Total Unique Children	50,379	

3.6.4 Cleaning of Fluoride Varnish Visit Dataset and Assembly of 'Nursery and School Fluoride Varnish Applications' Variable

To generate a 'Nursery and School Fluoride Varnish Applications' variable, firstly the Fluoride Varnish Visit Dataset was cleaned (Figure 3-5) to only keep those records where there was both a response of 'Yes' to the Varnish variable and 'Missing' to the Reason Varnish Not Applied variable (n = 74,563). Records were then kept for fluoride varnish applications that were prior to the child's inspection date (n = 74,774). The dataset was then filtered to keep one record of application per child per day (n = 74,563). This represented 24,613 (49%) unique children in the study.

Figure 3-5: Flow chart of the cleaning of the Fluoride Varnish Visit Dataset



A list of targeted nurseries and schools (along with the time periods when they were targeted) was generated. Any child who attended a nursery or school at a point in time when the establishment was being targeted for fluoride varnish application were themselves defined as 'Targeted' (n = 31,581) with those not attending one of these establishments defined as 'Not Targeted' (n = 18,798). Due to the low frequencies for children with seven contacts and beyond, these were tabulated into '7 plus contacts' to avoid releasing identifiable data (Table 3-17). Almost a quarter of children attending a targeted established did not receive a fluoride varnish application.

Children were only eligible for a fluoride varnish application in nursery from the age of two. It would be expected that children would likely only have a maximum of five to six fluoride varnish applications if applied twice per academic year as per the Childsmile programme guidelines. For the 'Nursery and School Fluoride Varnish' variable, children with more than five fluoride varnish applications were tabulated into a '5 plus applications' category (Table 3-18). Children with an NDIP inspection who had not attended a targeted establishment were assigned to a 'Not Targeted' category. The majority of children in the study (n = 31,581) had been targeted for a fluoride varnish application.

Table 3-17: Fluoride Varnish Applications in Nursery and School for Targeted Children

Fluoride Varnish Applications	n	(%)
0 applications	6,968	(22%)
1 application	4,770	(15%)
2 applications	4,682	(17%)
3 applications	5,323	(17%)
4 applications	5,483	(17%)
5 applications	3,655	(12%)
6 applications	657	(2%)
7 plus applications	43	(<1%)
Total Unique Children Targeted	31,581	

Table 3-18: Frequency of categories within the 'Nursery and School Fluoride Varnish Applications' Variable

Nursery and School Fluoride Varnish Applications	n	(%)
Not Targeted	18,798	(37%)
0 application	6,968	(14%)
1 application	4,770	(9%)
2 applications	4,682	(9%)
3 applications	5,323	(11%)
4 applications	5,483	(11%)
5 plus applications	4,355	(9%)
Total Unique Children	50,379	

3.6.5 Study Cohort Creation

A final study cohort dataset was created that would be used to undertake the outcome analysis of Childsmile. The variables retained were:

- The child's unique identification Index Number

- The four intervention variables (‘DHSW Contacts’, ‘Childsmile Dental Practice Contacts’, ‘Time Toothbrushing’ and ‘Nursery and School Fluoride Varnish Applications’) plus the ‘Dental Practice Fluoride Varnish Applications’ as these were the key activities of each of the four components of Childsmile.
- The oral health outcome measure ‘Caries Experience’.
- ‘SIMD Quintile’ which was re-categorised from the SIMD Decile and assigned to the NDIP outcome dataset
- ‘Age’ in years which is the age of the child on the date of their NDIP inspection.
- Sex i.e. the sex of the child as detailed on the source NDIP dataset.

3.7 Description of Childsmile Intervention Variables

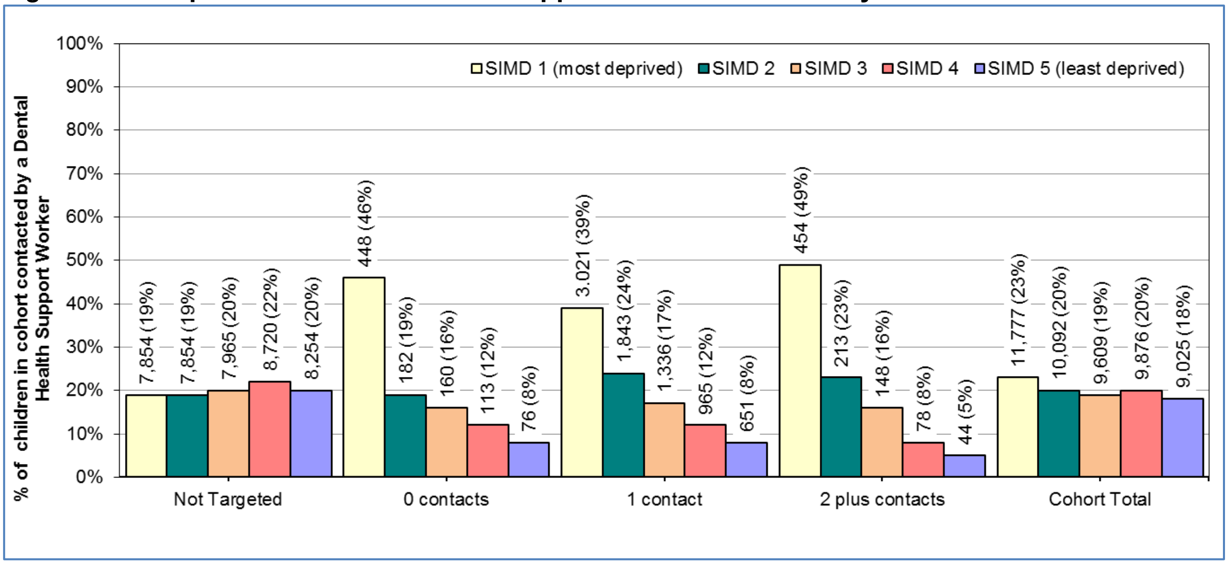
This section describes the distribution of each of the Childsmile intervention variables by SIMD, sex and age.

3.7.1 Description of ‘Dental Health Support Worker Contacts’ Variable

Figure 3-6 shows that there was an equal spread of children from the five SIMD quintiles across the ‘Not Targeted’ level with 19% (n= 7,854) in SIMD 1, the most deprived area, and 20% (n = 8,254) in SIMD 5, the least deprived area. For those children that were targeted, regardless of the number of contacts, there were more children from SIMD 1 than any other area, with the number of children in each SIMD quintile reducing as their level of deprivation reduced.

There was generally an even distribution of sex across each of the levels although there were 6% more males than females in the ‘Not Targeted’ group (Figure 3-7) which is a similar pattern to the cohort level. The majority of children in each level were five-years-old on the day of their dental inspection with no difference observed across the different number of contacts (Figure 3-8).

Figure 3-6: Proportion of 'Dental Health Support Worker Contacts' by SIMD Quintile



SIMD – Scottish Index of Multiple Deprivation

Figure 3-7: Proportion of 'Dental Health Support Worker Contacts' by sex

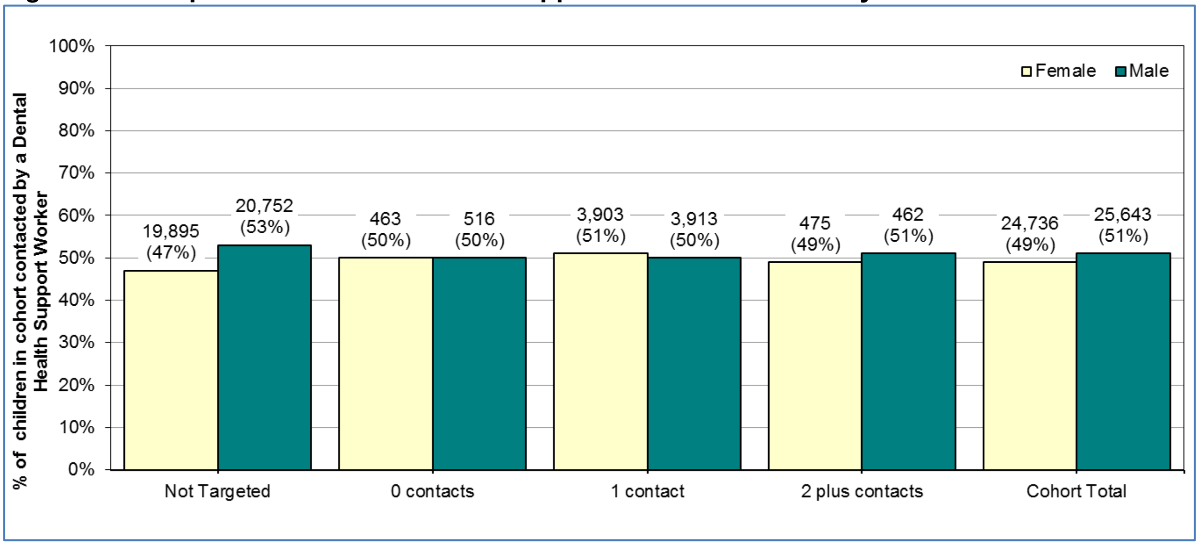
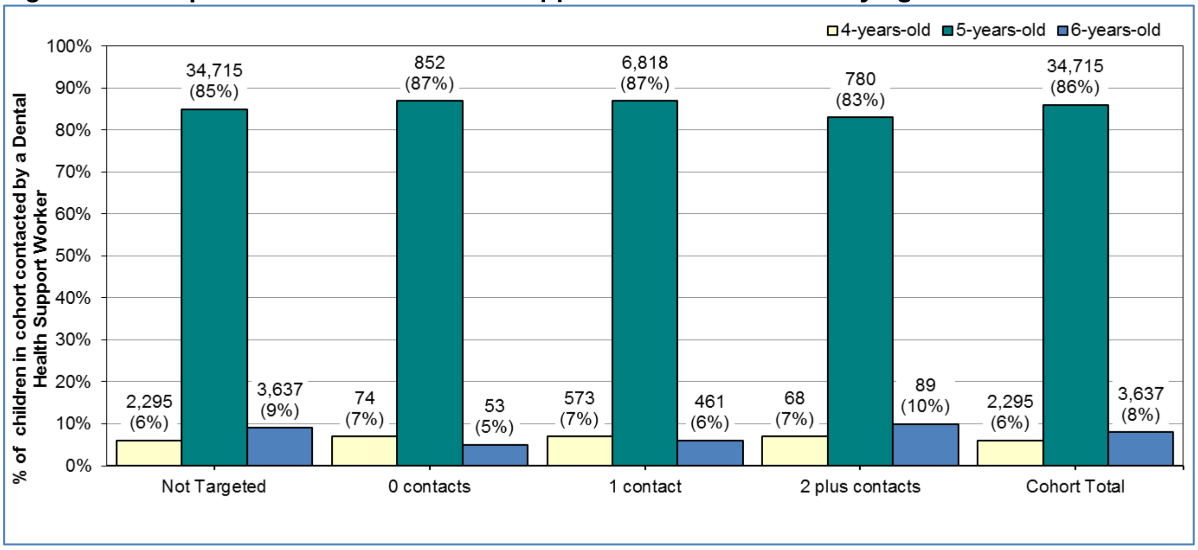


Figure 3-8: Proportion of 'Dental Health Support Worker Contacts' by age of NDIP Exam

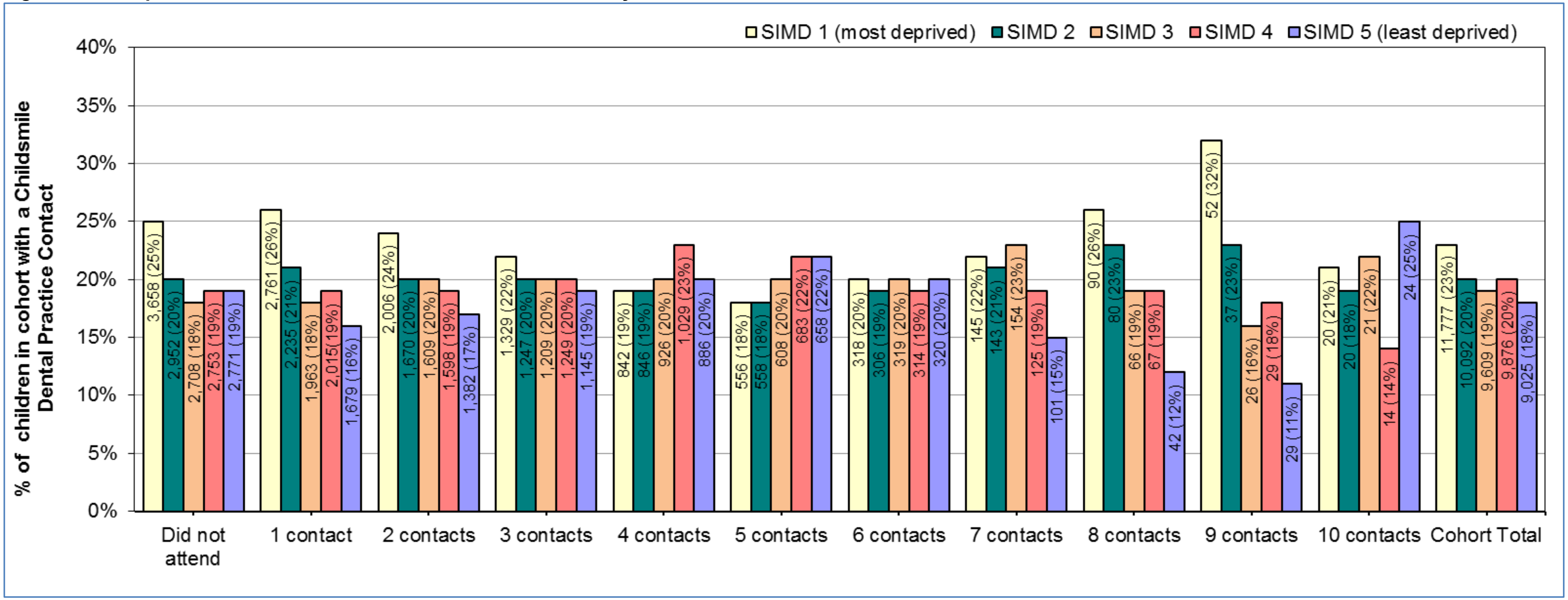


3.7.2 Description of ‘Childsmile Dental Practice Contacts’ Variable

A quarter of the children that never had a ‘Childsmile Dental Practice Contact’ were from SIMD 1 (n = 3,658) with the remaining children generally evenly distributed across the other four SIMD quintiles (Figure 3-9). It was a similar pattern of distribution for those children with two or three contacts. For four to six contacts, there was generally an even spread from each SIMD quintiles. The number of children decreased dramatically as the total number of contacts increased, with the number of children with seven to ten contacts much lower in comparison to the earlier totals with no obvious patterns of distribution observed.

There was generally an even distribution of sex across each of the levels from those with zero Childsmile contacts up to six contacts. Although there were differences in the sex distribution from seven contacts onwards, the numbers are very low in comparison to the lower number of contacts.

Figure 3-9: Proportion of 'Childsmile Dental Practice Contacts' by SIMD Quintile



SIMD – Scottish Index of Multiple Deprivation

Figure 3-10: Proportion of 'Childsmile Dental Practice Contacts' by sex

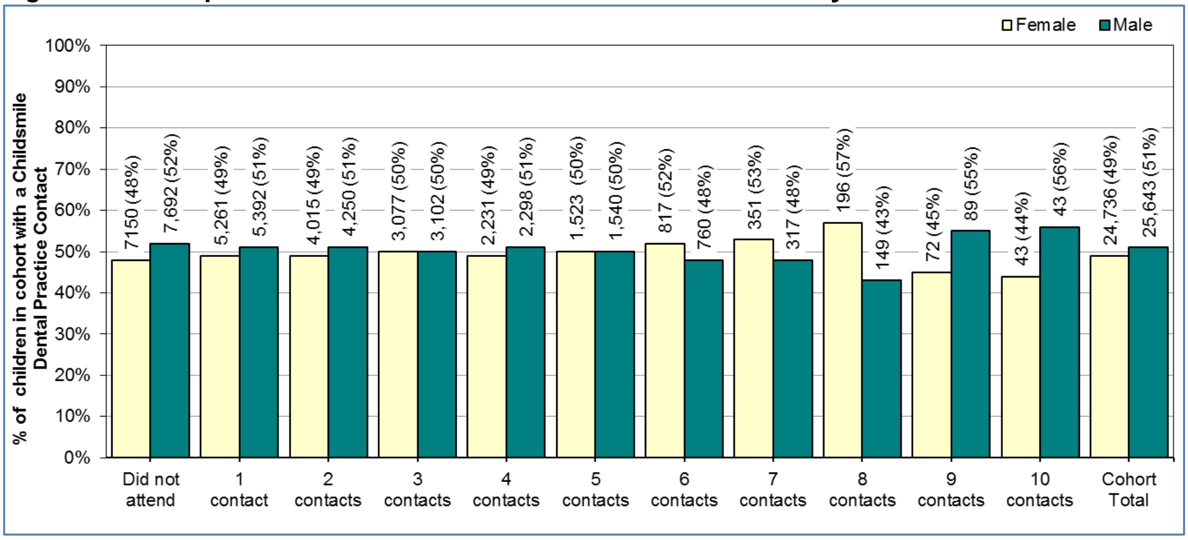
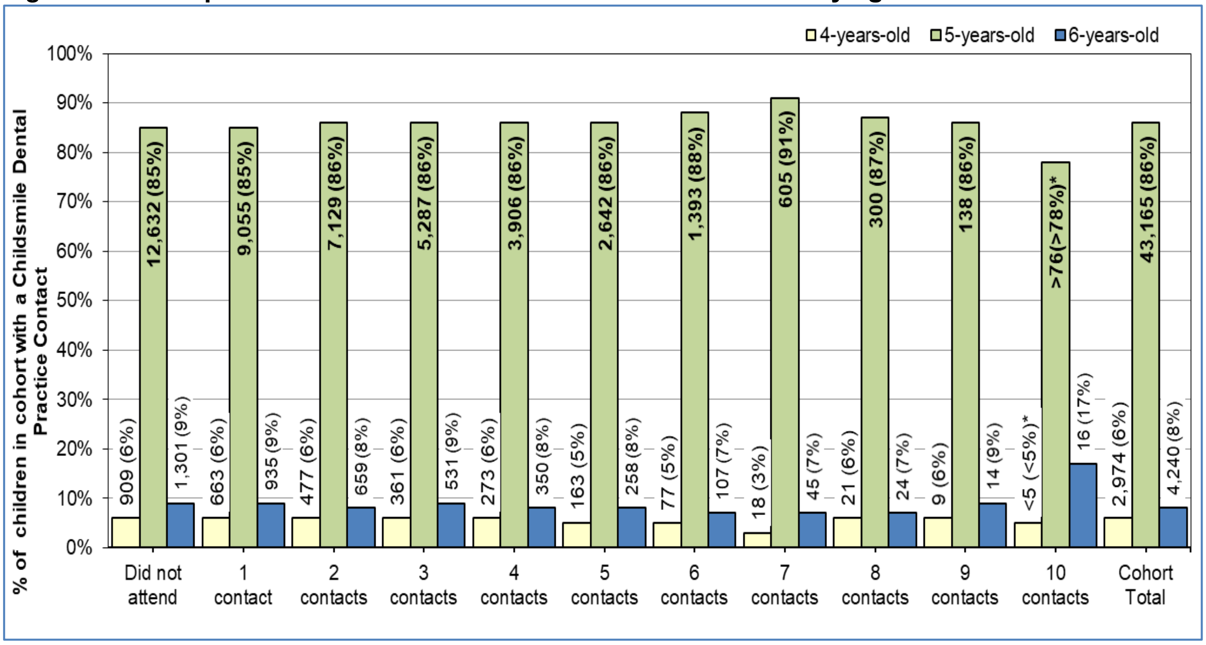


Figure 3-11: Proportion of 'Childsmile Dental Practice Contacts' by age of NDIP Exam

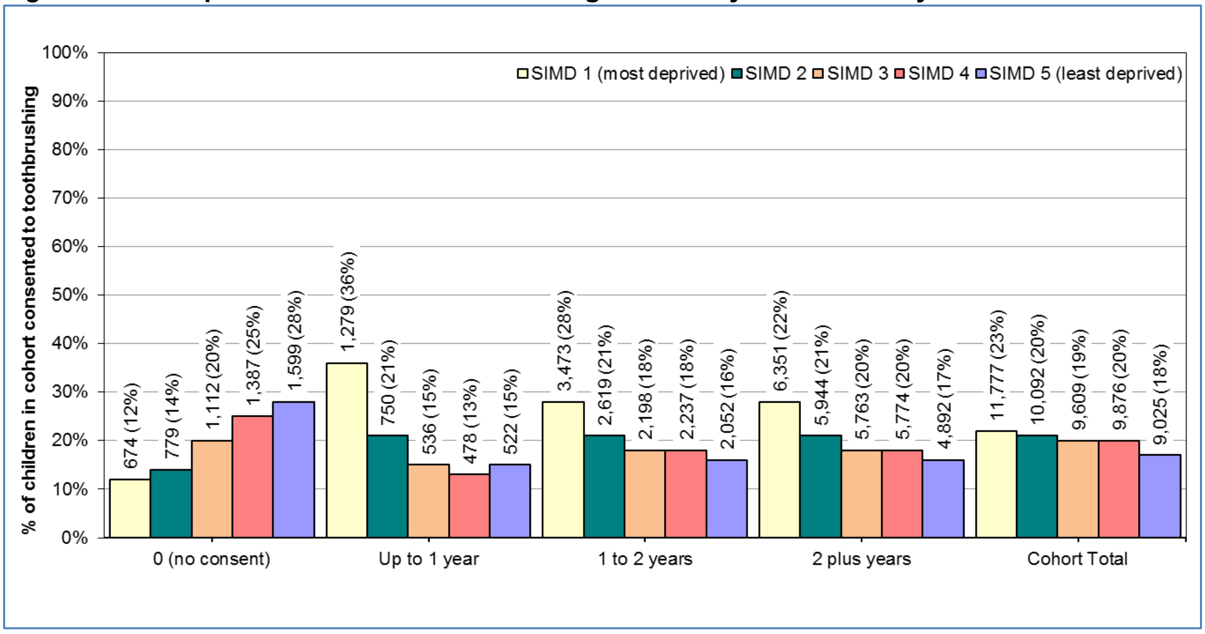


***frequencies and percentages altered to avoid releasing identifiable data**

3.7.3 Description of 'Time Toothbrushing' Variable

The number of children from SIMD 5 not participating in the toothbrushing programme was 1,599 (28%), which was more than double that of the least deprived area (SIMD 1). Participation in the supervised toothbrushing programme was greatest in children from the most deprived backgrounds (SIMD 1), regardless of the number of years participating in the programme (Figure 3-12).

Figure 3-12: Proportion of 'Time Toothbrushing' in nursery and school by SIMD Quintile



SIMD – Scottish Index of Multiple Deprivation

There was an even split of children by sex in both the group of children not toothbrushing and those that were (Figure 3-13). The majority of children were five-years-of-age across each of the levels and although there was slight variation in the number of children aged four or six-years-old across the number of years brushing.

Figure 3-13: Proportion of 'Time Toothbrushing' in nursery and school by sex

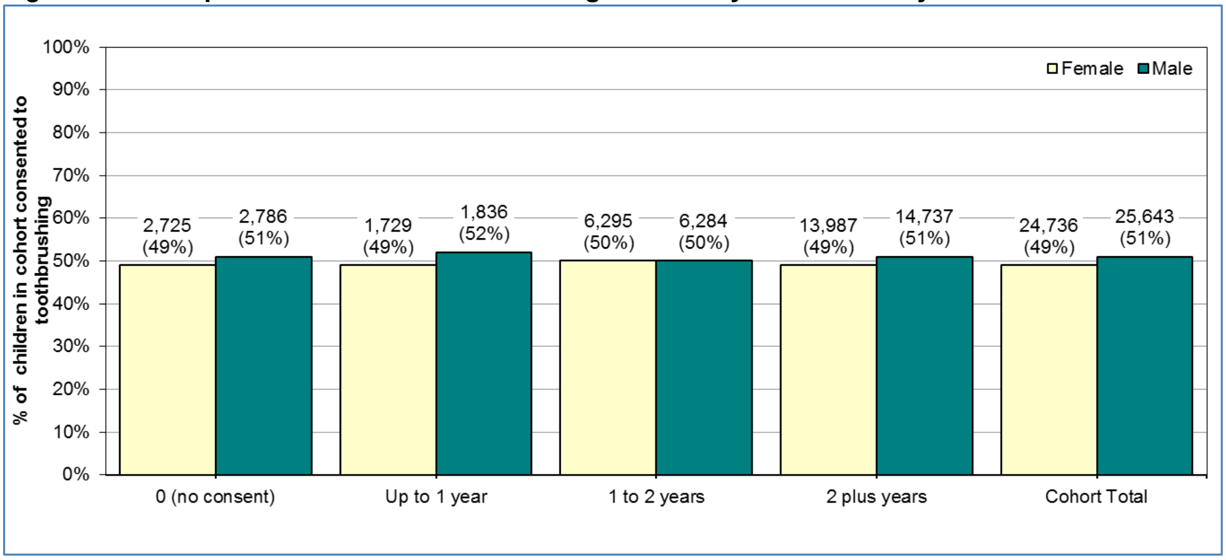
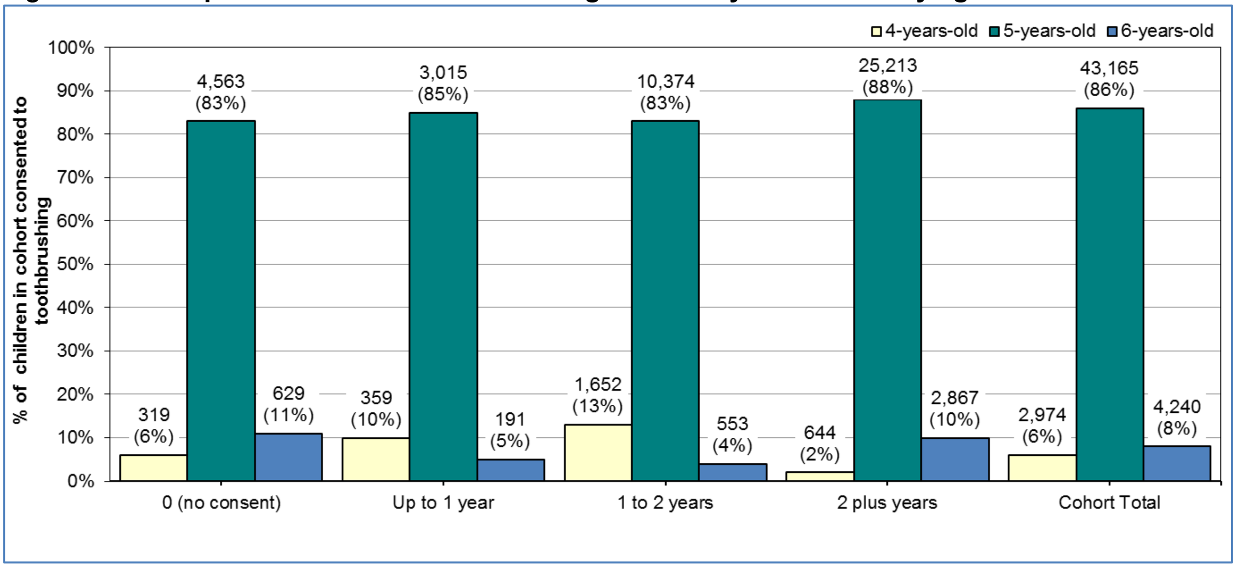


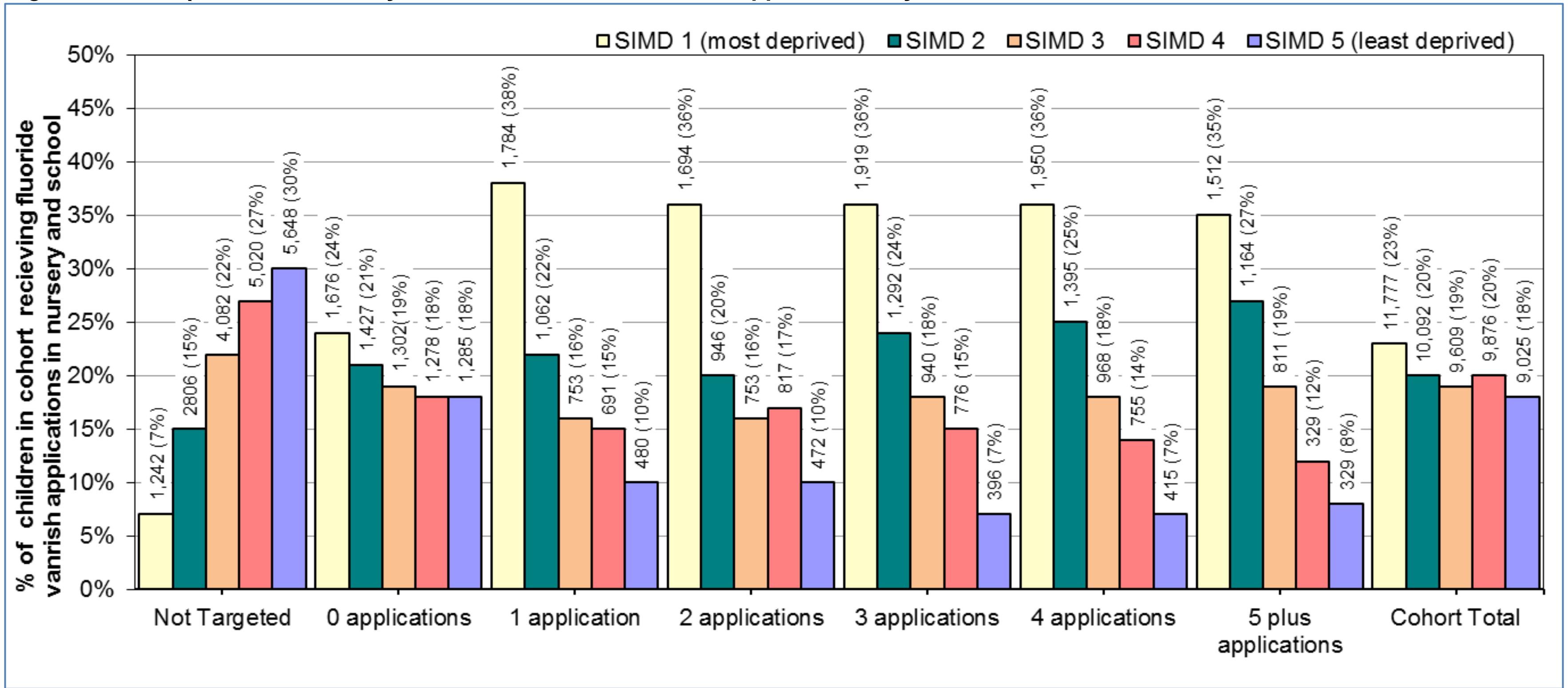
Figure 3-14: Proportion of 'Time Toothbrushing' in nursery and school by age of NDIP Exam



3.7.4 Description of 'Nursery and School Fluoride Varnish Applications' Variable

Figure 3-15 shows that only 7% (n = 1,242) of those children that were not targeted for a fluoride varnish application in nursery and school were from SIMD 1 with the number of children from each SIMD quintile not targeted increasing as the level of deprivation decreases. For those children that were targeted, within each level, around two thirds of the children were from SIMD 1 with the number of children from each of the other SIMD quintiles reducing with reducing deprivation.

Figure 3-15: Proportion of ‘Nursery and School Fluoride Varnish Applications’ by SIMD Quintile



SIMD – Scottish Index of Multiple Deprivation

There was generally an even distribution of sex across each of the groups although there were 5% more males (n = 3,659) than females within the group of children that were targeted but did not receive a fluoride varnish application (Figure 3-16).

Figure 3-16: Proportion of 'Nursery and School Fluoride Varnish Applications' by sex

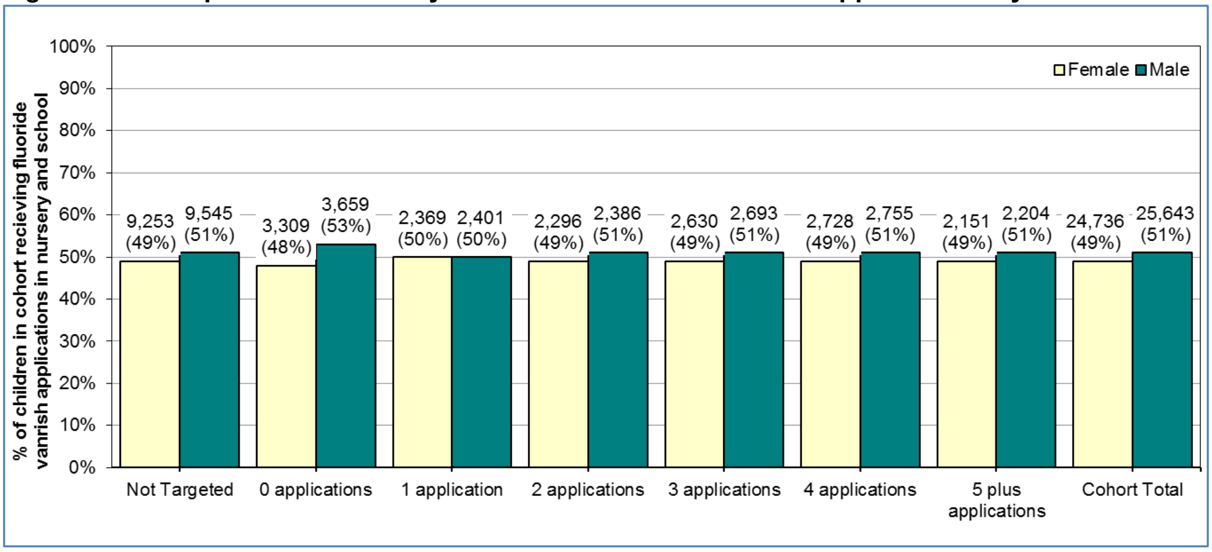
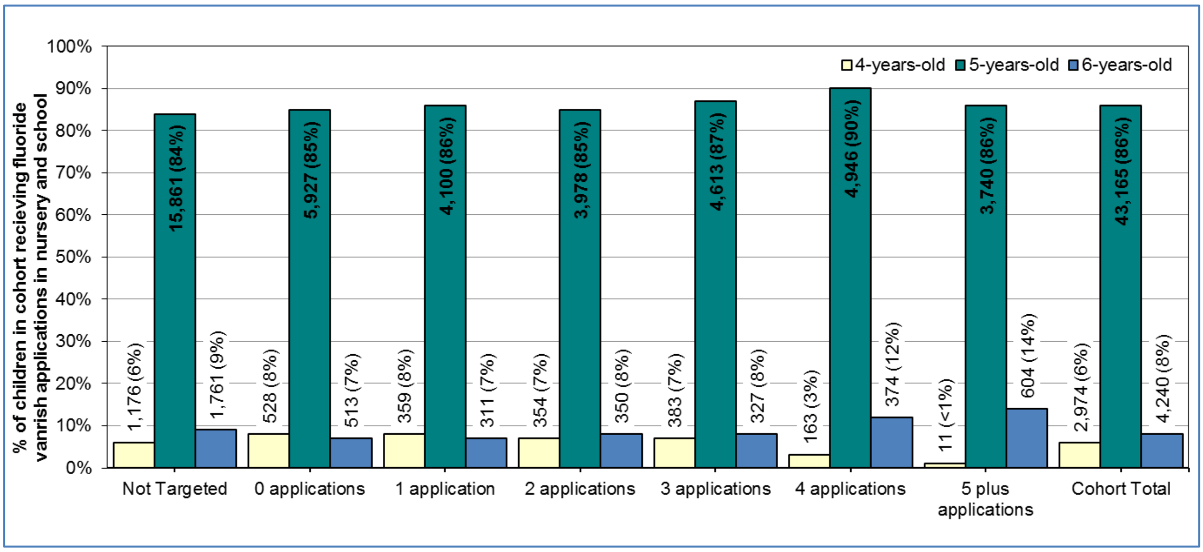


Figure 3-17: Proportion of 'Nursery and School Fluoride Varnish Applications' by age of NDIP Exam



3.8 Chapter 3 Summary

There was no socioeconomic bias observed during the cleaning of the 2014/2015 NDIP year with regards to children excluded due to data quality issues such as incorrect dates, although children from more deprived areas were more likely to be excluded for not having attended school on the day of inspection. This was not unexpected, however, as Scottish Government records had indicated that children from the most deprived areas were more likely to be absent from school than their more affluent counterparts.

Overall, the quality and completeness of the datasets to be used in the study was high with no concerns highlighted when the completeness of the variables were checked. There were no significant differences in the data between the children that had been excluded from the study with those that were being included. Any differences that were observed could mostly be attributed to the fact that the children from more deprived areas were more likely to be excluded for being absent from school on the NDIP date and therefore more likely to be absent on other days also. Most importantly, there were no differences in the oral health of the children in either group, whether that be the oral health measures in the NDIP dataset, or the brief oral health information gathered when the child was given a fluoride varnish application when at nursery or school. Of equal importance was the observation that the rates of Childsmile interventions across the multiple Childsmile components remained consistent across both the included and excluded groups, indicating no systematic bias for those variables that will be used to measure the impact of Childsmile on oral health outcomes.

A detailed description of the demographics of each Childsmile intervention was provided that can be used as a tool in the interpretation of outcome analysis results presented in Chapter Four.

Chapter 4 – Statistical Analysis and Results

4.1 Chapter 4 Introduction

This chapter details the results of the analysis of the cohort to evaluate the impact of exposure to the Childsmile components on Obvious Caries Experience (referred from this point onwards as 'Caries Experience') in Primary One (five-year-old children as the outcome measure. The main aim of this chapter is to evaluate each of the four Childsmile interventions (Dental Health Support Worker Contacts ('DHSW Contacts'); Childsmile Contacts at a Dental Practice; Time Consented to Toothbrushing in the supervised nursery and school programme ('Time Toothbrushing'); and Nursery and School Fluoride Varnish Applications, with regards to their association with Caries Experience.

The objectives were to:

1. Describe the delivery of Childsmile component by area-based deprivation to determine if the Childsmile programme is being delivered as intended.

2. Investigate the association between potential confounders and Caries Experience.

3. Evaluate each of the Childsmile components individually to investigate their association with Caries Experience.

4. Evaluate the independent effect of each of the Childsmile components on Caries Experience.

5. Identify which Childsmile component(s) explain the greatest amount of the reduction in Caries Experience.

6. Compare the impact of the four Childsmile components on Caries Experience relative to one another in the most deprived communities.

7. Explore the difference in the Caries Experience of children that received fluoride varnish applications when they attended a Childsmile dental practice in comparison to those children who had attended but had not received fluoride varnish.

4.2 Statistical Analysis

This section describes the different analytical approaches used to address each research question and objective. All statistical analyses undertaken in the chapter were completed using SAS Enterprise Version 5.1.

4.2.1 Assessing whether Childsmile Programme is being delivered as envisaged

Individual components were described by the distribution of the ‘dose’ i.e. the number of contacts, time toothbrushing or the number of fluoride varnish applications within each national Scottish Index of Multiple Deprivation quintile (2009 version), firstly for every child in the cohort and then only for those targeted for the ‘DHSW Contacts’ and ‘Nursery and School Fluoride Varnish Applications’ components. The frequency and percentages of doses were then compared for any obvious differences in the delivery of a component between deprivation groups. National SIMD was used throughout the analyses in this chapter to ensure assessment in relation to the most deprived communities at the Scottish population-wide level. However, the actual targeting in the implementation of the programme was done by health boards who used their local health board level SIMD indices - to enable them to target the 20% of children living in the most deprived areas within their board area. For example, there is no national SIMD 1 in either NHS Shetland or NHS Orkney. Therefore, children from the 20% most deprived areas in these two health boards would not be in the 20% most deprived areas nationally. The implications of the difference between local and national SIMD will be picked up in the Discussion (Chapter 5).

Logistic regression with SIMD as a continuous variable was then used to test whether there was an increasing or decreasing trend in those children with at least one dose of a component across the deprivation groups.

4.2.2 Exploring the Association between Potential Confounders and Caries Experience

Although there are many potential confounding factors for Caries Experience such as behavioural factors, only the area-based deprivation status via SIMD, the age of the child at the dental inspection, and the sex of the child (as recorded on the NDIP database) were available from the routine administrative data sources.

Firstly, potential confounders were cross tabulated by Caries Experience by computing counts and percentages. Then each of the three potential confounders were analysed univariately by logistic regression (Sections 4.4.1.1 to 4.4.1.3). Odds ratios were calculated using suitable referent categories. Wald p-values and 95% confidence intervals were calculated for each odds ratio. Likelihood ratio test p-values were created for each variable as a whole (i.e. using multiple degrees of freedom for each odds-ratio within the variable). The predictive ability of each variable was calculated using the 'c-index', i.e. the area under the Receiving Operating Characteristic (ROC) curve. Note that a variable with no predictive ability has a c-index of 0.5. The maximum c-index is 1.00 which indicates perfect discrimination (Harrell Jr et al., 1984; Altman and Bland, 1994; Hosmer Jr et al., 2013).

4.2.3 The individual effect of Childsmile Components on Caries Experience (Model One)

The association between the Childsmile components and Caries Experience were analysed using binary logistic regression, as a univariate analysis as well as being adjusted for SIMD, age, and sex. Unadjusted univariate and adjusted odds ratios and 95% confidence intervals were presented.

4.2.4 Interactions between Childsmile Components and Confounder Variables and Independent effects of the Childsmile components on Caries Experience (Model Two)

In the next analysis stage, it was important to have the relationship between variables properly specified. An interaction test was undertaken to see whether the effects of the Childsmile components on Caries Experience were modified by the three potential confounders. Where an interaction that was significant at the 5% level was observed, the results of the Model One adjustment for the component are reported by the interacting covariate (i.e. partitioned).

In the multivariable model, all Childsmile components were included in addition to the three potential confounders: SIMD, age and sex. Where interactions were observed between Childsmile components and the potential confounders, these were also included in the model (although this final adjustment was only made for components where there had been no interactions observed). Adjusted odds ratios and 95% confidence intervals were presented.

4.2.5 Exploring which Childsmile Components Explain the Greatest Amount of Variation in Caries Experience (Model Three)

To consider the main effects of the Childsmile components, i.e. which components explain most of the variation in Caries Experience, a forward stepwise model (Cordell and Clayton, 2002) was undertaken as an exploratory measure to investigate all of the Childsmile components in a single model.

The forward stepwise model routine by logistic regression is cumulative and therefore the χ^2 and p-value are adjusted by the variables already entered by the algorithm. By definition, the variable in the first step is not adjusted by the other components.

SIMD, sex and the age of the child were all included as fixed factors in the model. Each of the four Childsmile components were entered in sequence into the model with the most significant added first.

4.2.6 Variation in Childsmile Dental Practice Contacts

Finally, to investigate the effect of Childsmile Dental Practice Contacts on Caries Experience, further analysis of the components delivered in practice was performed, specifically, whether fluoride varnish applications were received in the dental practice was addressed. There were two types of Childsmile Dental Practice Contacts: contacts with oral health advice only, and contacts with oral health advice and fluoride varnish applications. The two types of contacts were looked at separately - for children who had never received a fluoride varnish application, and for children who had received a fluoride varnish application at every visit. The category ‘0 Childsmile contacts’ was retained as the referent category for these two subsets.

The association between each of the two subgroups and Caries Experience were analysed using binary logistic regression, as a univariate analysis and then adjusted by SIMD, age, and sex. An interaction test was undertaken on each of the sub-groups to see if the effect of the two dental practice components on Caries Experience were modified by the three potential confounders.

4.3 Results: Delivery of Childsmile Components

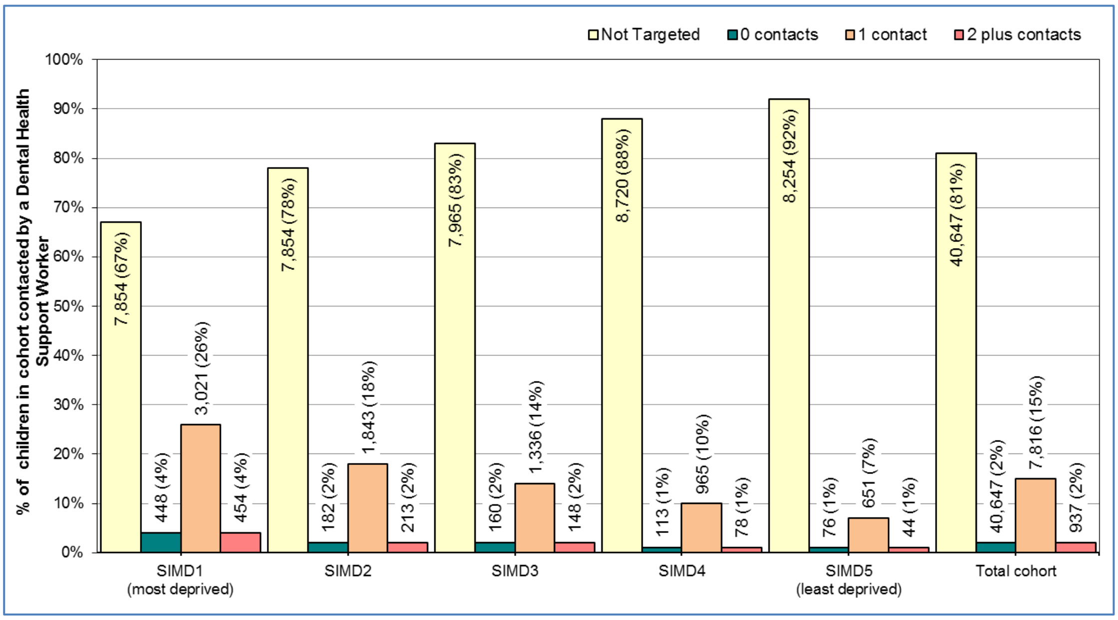
This section analyses each Childsmile component to investigate whether each was being delivered as envisaged by the programme in terms of the targeting reach and universal coverage.

4.3.1 Delivery of the Dental Health Support Worker Component

It was envisaged that the DHSW component would be targeted at children living in the most deprived areas.

The majority (81%) of children in the cohort were not targeted for a DHSW contact (Figure 4-1). Within SIMD 1, the most deprived quintile, 67% (n = 7,854) of children were not targeted i.e. only 33% of children that should have been targeted were. The rate of children targeted decreased with deprivation from 33% of children in the most deprived quintile to 8% of those from the least deprived quintile. Some of the children that were targeted did not have any contact (i.e. unable to make contact). The rate of children in the cohort with any contact with a DHSW also decreased with deprivation from 30% of children (n = 3,475) in the most deprived quintile to 8% (n = 695) of those from the least deprived quintile.

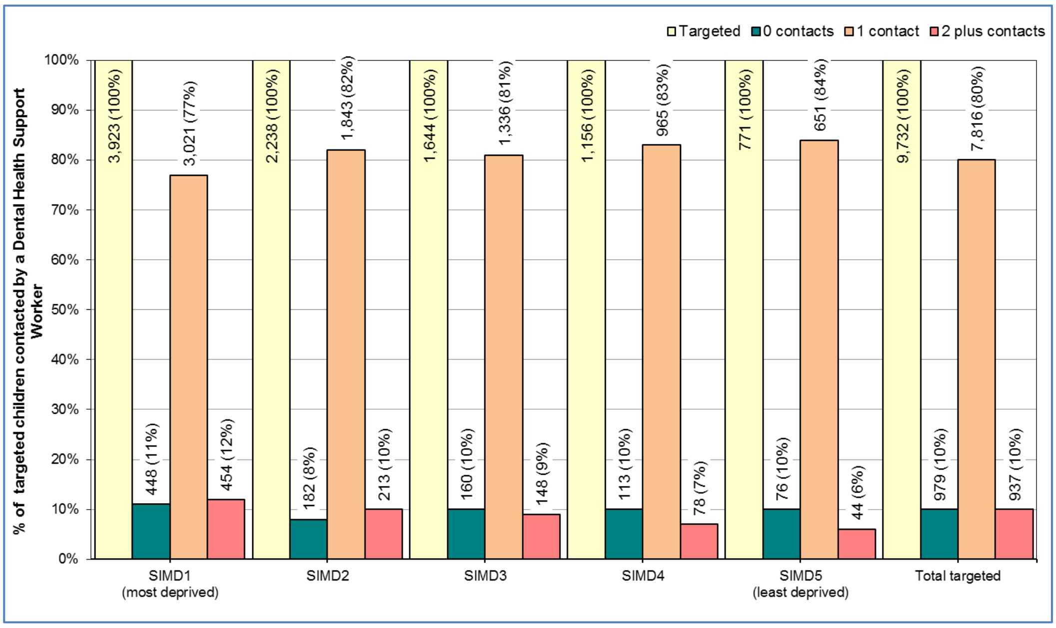
Figure 4-1: Proportion of children within each SIMD quintile by 'Dental Health Support Worker Contacts' – full cohort



SIMD – Scottish Index of Multiple Deprivation

Of those children targeted for a DHSW contact, there was a slight gradient in the percentage of children from each SIMD quintile receiving just one contact from 77% (n = 3,012) in SIMD 1 to 84% (n = 651) in SIMD 5 (Figure 4-2). The gradient went in the opposite direction for children with two or more contacts with 12% (n = 454) in SIMD 1 to 6% (n = 44) in SIMD 5. The rate of targeted children with any contact with a DHSW did not change with deprivation with 89% of children from the most deprived quintile and 90% of those from the least deprived quintile having at least one contact.

Figure 4-2: Proportion of children within each SIMD quintile by 'Dental Health Support Worker Contacts' – targeted children



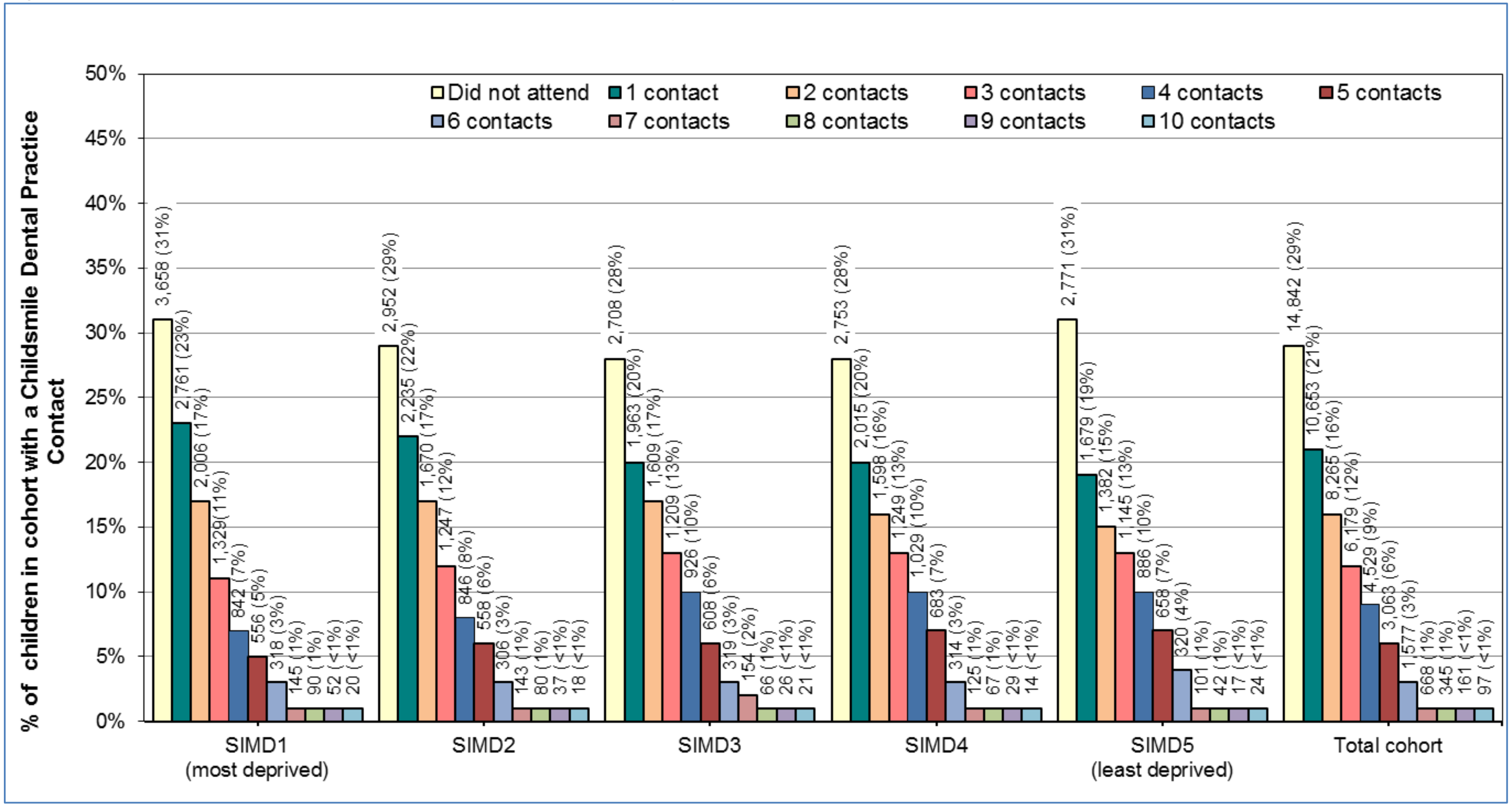
SIMD – Scottish Index of Multiple Deprivation

4.3.2 Delivery of the Childsmile Dental Practice Component

Childsmile Dental Practice Components were a universal component of the programme and therefore it was the intention of the programme that every child would have an equal opportunity to attend a Childsmile Dental Practice appointment.

The rates of dental practice contacts were relatively stable across each of the SIMD quintiles (Figure 4-3). For example, 31% of children from SIMD 1 (n = 3,658) and 31% from SIMD 5 (n = 2,771) never had a Childsmile Dental Practice contact or in other words, 69% of children from SIMD 1 and SIMD 5 had at least one Childsmile Dental Practice contact. Even as the rates of number of contacts increased the rates remained very similar i.e. the percentage of children with six contacts was 3% in SIMD 1 (n = 318) and 4% (n = 320) in SIMD 5.

Figure 4-3: Proportion of children within each SIMD quintile by 'Childsmile Dental Practice Contacts' – full cohort



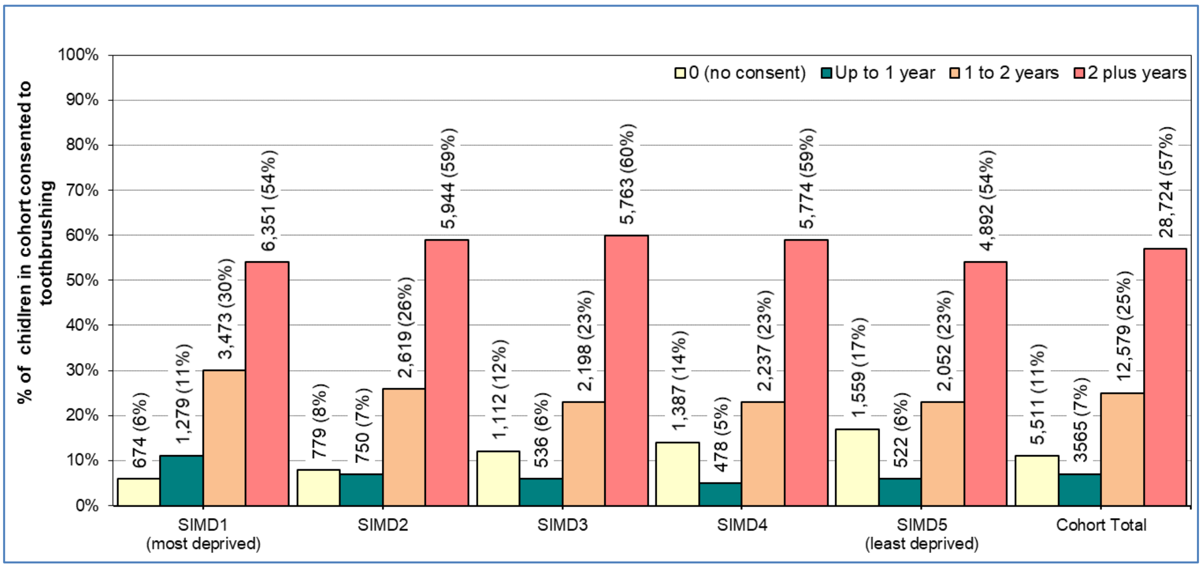
SIMD – Scottish Index of Multiple Deprivation

4.3.3 Delivery of the Toothbrushing Component

The supervised toothbrushing component of Childsmile was available universally to children attending nursery school.

The rate of children who were not consented to toothbrushing increased as the level of deprivation decreased (Figure 4-4). The rates of children toothbrushing for one and two years were highest in SIMD 1 (11% and 30% respectively). Children with two years or more of toothbrushing was slightly lower among children from both the most and least deprived quintiles (54%) in each in comparison to the other three quintiles (SIMD 2, 3 and 4), although when combining children with 1 to 2 years and 2 plus years of toothbrushing, 84% of children living in the most deprived area had one or more years of toothbrushing in comparison to 77% in the most affluent area.

Figure 4-4: Proportion of children within each SIMD quintile by 'Time Toothbrushing' – full cohort



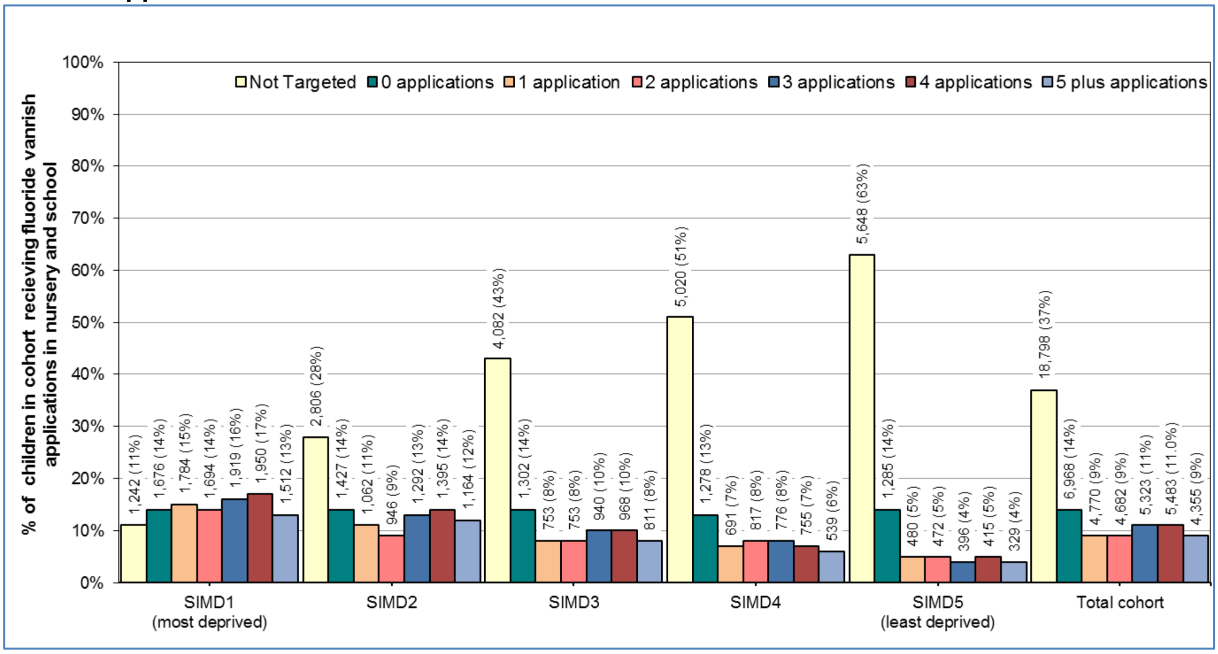
SIMD – Scottish Index of Multiple Deprivation

4.3.4 Delivery of the Nursery and School Fluoride Varnish Application Component

Fluoride Varnish Applications were offered to every child attending a targeted nursery and school. This targeting was based on the SIMD profile of the children on the roll of the nursery and school – aiming to reach the highest proportion of children from the most deprived (SIMD 1) areas.

Of the cohort, 63% (n = 31,581) of children were targeted for a fluoride varnish application at nursery and school (Figure 4-5 and 4-6). Within SIMD 1, 11% of the children (n = 1,242) were not targeted, i.e. 89% of children that should have been targeted were targeted. There was a steep gradient with the number of children targeted reducing as the level of deprivation decreased with 63% in SIMD 5 (n = 5,648) not targeted.

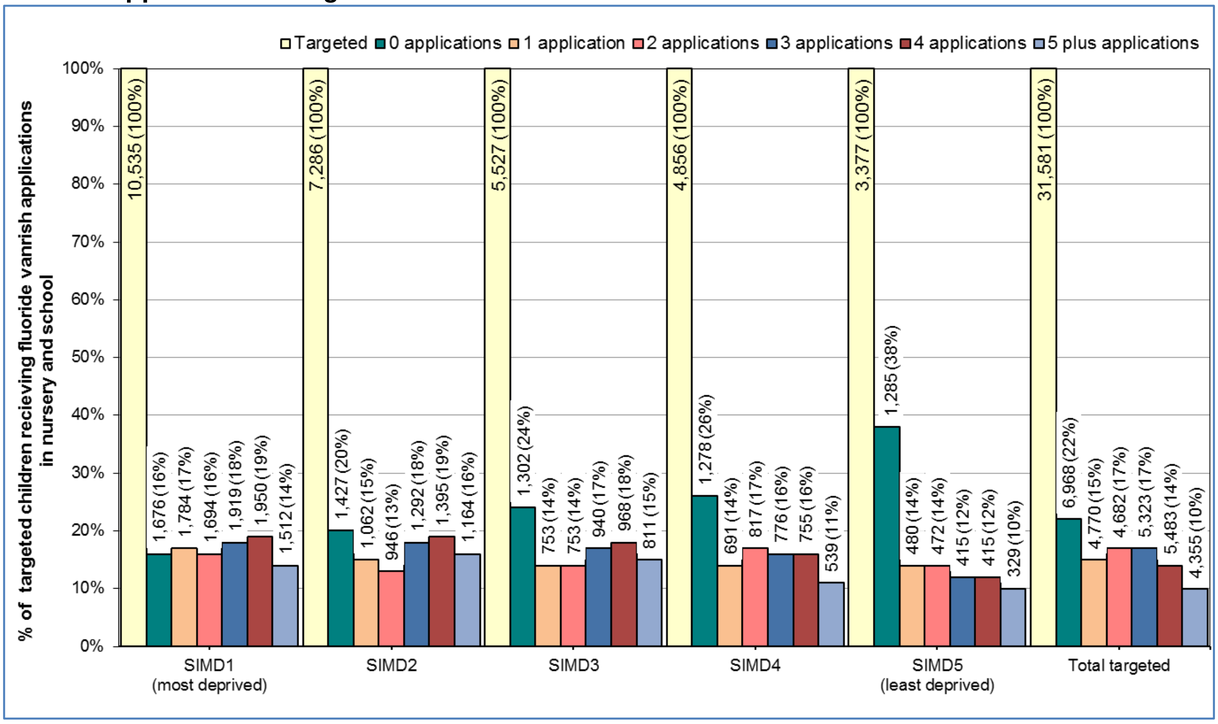
Figure 4-5: Proportion of children within each SIMD quintile by 'Nursery and School Fluoride Varnish Application' – full cohort



SIMD – Scottish Index of Multiple Deprivation

Of those children that were targeted for a fluoride varnish application at nursery and school, 84% of SIMD 1 (n = 8,859) received a varnish, with the rate of varnishing decreasing with deprivation to 62% (n = 2,092) of the targeted children in SIMD 5 receiving a fluoride varnish application (Figure 4-6). Monitoring data from 2015 reported that 12% of all children in Scotland targeted were not granted consent from their parent or carer. Children may also have been absent on the day of application (Central Evaluation & Research Team, 2015). There were no obvious differences in the rates of application among the four most deprived quintiles as the number of varnishes increased; however, the rates of applications in SIMD 5, the most affluent quintile, were the lowest regardless of the number of applications.

Figure 4-6: Proportion of children within each SIMD quintile by 'Nursery and School Fluoride Varnish Application' – targeted children



SIMD – Scottish Index of Multiple Deprivation

4.3.5 Access to the Childsmile Components (ever / never contacted)

Overall, of the total number of children in the cohort, 17% had at least one DHSW contact, 71% had at least one Childsmile Dental Practice Contact, 89% had consented to the supervised toothbrushing programme, and 49% had received at least one fluoride varnish in nursery or school.

This section summarises contact with the Childsmile components in terms of whether there was any contact overall and by SIMD.

4.3.5.1 Dental Health Support Workers

Within the cohort, only 30% (n = 3,475) of children living in the 20% most deprived areas in Scotland had at least one contact with a DHSW. The rate of children with at least one contact declined further in the more affluent areas, with only 8% having of children in the least deprived having had a contact (Figure 4-7). This was a significant continuous trend (OR = 0.67; 95% CI = [0.65 to 0.68]) that had a fair level of prediction (c index = 0.65) that children were more likely to have at least one DHSW contact as deprivation increased (Table 4-1).

4.3.5.2 Nursery and School Fluoride Varnish Programme

A similar trend to the DHSW component was observed for children receiving at least one fluoride varnish application in nursery and school, but with a substantially higher proportion (75%, n = 8,859) of children from the most deprived areas (SIMD 1) receiving at least one fluoride varnish application and 23% (n = 2,092) of children from the least deprived (SIMD 5) areas receiving it (Figure 4-7). This was a significant continuous trend (OR = 0.58; 95% CI = [0.57 to 0.58]) that had a good prediction level (c index = 0.71) that children were more likely to have at least one fluoride varnish application in nursery and school settings as deprivation increased (Table 4-1).

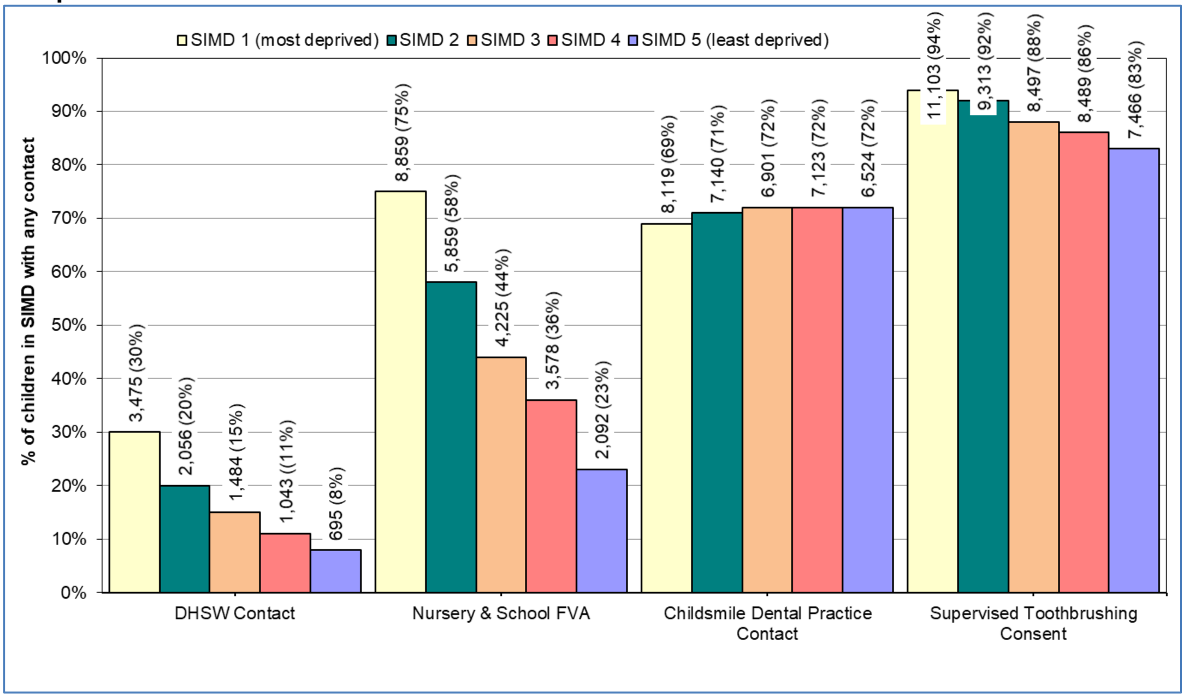
4.3.5.3 Childsmile Dental Practice

Of the study population, 69% (n = 8,119) of children living in the most deprived areas had at least one Childsmile contact at a dental practice. There was a slightly higher rate in the less deprived areas, with 72% (n = 6,524) of those in the least deprived areas having at least one contact (Figure 4-7). The trend was marginally significant (OR = 1.04; 95% CI = [1.03 to 1.06]) and the very low c-index of 0.52 indicated that deprivation only had a very slight predictability effect of a child having at least one Childsmile contact at a dental practice (Table 4-1).

4.3.5.4 Supervised Toothbrushing Programme

There was high percentage coverage of the supervised nursery and school toothbrushing component across all SIMD deprivation quintiles. There was, however, a significant continuous trend in the rate of children consented into the supervised toothbrushing programme as deprivation decreased (OR = 0.73; 95% CI = [0.72 to 0.75]) with 94% (n = 11,103) of children from the most deprived areas having consent to participate compared to 83% (n = 7,466) of children from the least deprived areas (Figure 4-7). The c-index of 0.62 indicated that there was a good level of prediction associated with the level of deprivation in relation to consent (Table 4-1).

Figure 4-7: Proportion of children within each SIMD quintile with any contact by Childsmile component



SIMD – Scottish Index of Multiple Deprivation; DHSW – Dental Health Support Worker; FVA – Fluoride Varnish Application

Table 4-1: Association between SIMD and 'Ever Contacted' with the Childsmile components

Childsmile Component	**OR**	**95% CI**		**p-value**	**c-index**
Dental Health Support Worker Contact	0.67	(0.65,	0.68)	<0.001	0.65
Nursery and School Fluoride Varnish Application	0.58	(0.57,	0.58)	<0.001	0.71
Childsmile Dental Practice Contact	1.04	(1.03,	1.06)	<0.001	0.52
Consented to Supervised Toothbrushing	0.73	(0.72,	0.75)	<0.001	0.62

4.4 Results: Association of Childsmile Components on Caries Experience

4.4.1 Association between Potential Confounders and Caries Experience

4.4.1.1 Association between Sex and Caries Experience

This variable has two categories: ‘Female’ and ‘Male’. Male patients were the arbitrarily selected reference category in this analysis.

Table 4-2: Association between sex and Caries Experience

Sex	Caries Experience n	%	No Caries Experience n	%	Total	OR	95% CI	p-value
Female	7129	(29%)	17607	(71%)	24736	0.91	(0.87, 0.94)	<.001
Male	7903	(31%)	17740	(69%)	25643	-	Referent	-
Total	15032	(30%)	35347	(70%)	50379			

Logistic Regression Results

Type 3 Results:	Chi-Square	Df	p-value	C-index
	24.03	1	<0.001	0.51

In the cohort, females had 9% lower odds of developing caries than males (OR = 0.91; 95% CI = [0.87 to 0.94]). In absolute terms, 29% (7129) of females had Caries Experience compared to 31% (7903) of males: an absolute risk difference of 2%.

4.4.1.2 Association between Child Age and Caries Experience

The variable 'Age' at time of measurement of the outcome variable (Caries Experience) has three categories: '4 years old', '5 years old' and '6 years old'. Those children that were five years old on the date of their NDIP inspection were selected as the referent category in the analysis as this was the age most children would be at their dental inspection and therefore it can be compared with children with one year less or additional exposure to oral health risk factors.

Table 4-3: Association between age and Caries Experience

Age	Caries Experience n	%	No Caries Experience n	%	Total	OR	95% CI		p-value
4 years old	788	(27%)	2186	(74%)	2974	0.85	(0.78,	0.93)	<0.001
5 years old	12847	(30%)	30318	(70%)	43165	-	Referent		-
6 years old	2843	(33%)	2843	(67%)	4240	1.16	(1.08,	1.24)	<0.001
Total	15032	(30%)	35347	(70%)	50379				

Logistic Regression Results

Type 3 Results:	Chi-Square	Df	p-value	C-index
	35.50	2	<0.001	0.51

As expected, caries rates increased with age. The percentage of children with Caries Experience increased from 27% (n = 788) at age four to 33% (n = 2,846) at age six.

Compared to children aged 5 years, those aged 4 years were 15% (OR=0.85; 95% CI= [0.78 to 0.93]) less likely to have Caries Experience, whereas those aged 6 years were 16% more likely (OR = 1.16; 95% CI = [1.08 to 1.24]).

4.4.1.3 Association between Area-based Deprivation (SIMD) and Caries Experience

The variable 'SIMD' has five categories: '1', '2', '3', '4' and '5' with the first category consisting of children living in the 20% most deprived areas of Scotland up to the fifth category with children living in the 20% least deprived areas of Scotland. Children with a SIMD score of 5 were selected as the referent level in this analysis due to children in this level being traditionally associated with lower rates of Caries Experience.

Table 4-4: Association between area-based deprivation (SIMD) and Caries Experience

SIMD	Caries Experience n	%	No Caries Experience n	%	Total	OR	95% CI		p-value
1 (most deprived)	5310	(45%)	6467	(55%)	11777	4.39	(4.10,	4.70)	<0.001
2	3549	(35%)	6543	(65%)	10092	2.90	(2.70,	3.11)	<0.001
3	2597	(27%)	7012	(73%)	9609	1.98	(1.84,	2.13)	<0.001
4	2154	(22%)	7722	(78%)	9876	1.49	(1.38,	1.61)	<0.001
5 (least deprived)	1422	(16%)	7603	(84%)	9025	-	Referent		-
Total	15032	(30%)	35347	(70%)	50379				

Logistic Regression Results				
Type 3 Results:	**Chi-Square**	**Df**	**p-value**	**C-index**
	2515.12	4	<0.001	0.64

SIMD: Scottish Index of Multiple Deprivation.

Forty-five percent (5,310) of children living in the 20% most deprived areas of Scotland had Caries Experience compared to 16% (1,422) of children living in the 20% least deprived areas, and there was a dose-like relationship increasing with deprivation quintile (Table 4-4).

The odds of Caries Experience increased as a child's deprivation status worsened. Those children living in the 20% percent most deprived area were over four times (OR = 4.39; 95% CI = [4.10 to 4.70]) more likely to have Caries Experience than those living in the 20% least deprived area.

Of the three potential confounders, SIMD was the most strongly associated to Caries Experience with a c-index 0.64. Both the sex and the age of the child had a very small c-index of 0.51.

4.4.2 Association between Childsmile Components and Caries Experience (Model One)

4.4.2.1 Association between the Number of Dental Health Support Worker Contacts and Caries Experience

The logistic regression results of Caries Experience according to ‘DHSW Contacts’ adjusted by SIMD, Sex, and Age are presented in Table 4-5. The variable ‘DHSW Contacts’ has four categories: ‘Not Targeted’, ‘0 contacts’, ‘1 contact’, and ‘2 plus contacts’. Children targeted for a DHSW contact who did not receive a contact (‘0 contacts’) were the referent category selected in this analysis so that the odds of Caries Experience could be compared in relation to this as the number of contacts increased.

After adjustment, when compared to those children targeted but not reached by a DHSW, those not targeted had lower odds of Caries Experience (Adjusted Odds Ratio = 0.63; 95% CI = [0.55 to 0.72]).

Those who were targeted and who received only one contact were 37% less likely to have Caries Experience than those targeted and not reached (AOR = 0.63; 95% CI = [0.54 to 0.72]) whereas those receiving two or more contacts were no more likely to Caries Experience than those targeted and not reached (AOR = 0.91; 95% CI = [0.76 to 1.10]).

The type-3 index c-index value of 0.65 indicated that this model had a fair association with reduction in Caries Experience, but the c-index will be determined by the strong effect of SIMD. SIMD on its own has a c-index of 0.64 with a massive chi-square of 2515.12. Note that c-index only goes up when other variable are added to the model, so an increase of 0.64 to 0.65 means that little predictive value was added.

Table 4-5: Logistic Regression of 'Dental Health Support Worker Contacts' in Relation to Caries Experience: Unadjusted and Model One Adjustment*

Number of Contacts	Caries Experience n	%	No Caries Experience n	%	Total	Unadjusted OR	95% CI		p-value	Model One AOR	95% CI		p-value
Not Targeted	11,547	(28%)	29,100	(72%)	40,647	0.48	(0.42,	0.55)	<0.001	0.63	(0.55,	0.72)	<0.001
0 contacts	442	(45%)	537	(55%)	979	-	Referent		-	-	Referent		-
1 contact	2,624	(34%)	5,192	(66%)	7,816	0.61	(0.54,	0.70)	<0.001	0.63	(0.54,	0.72)	<0.001
2 plus contacts	419	(45%)	518	(55%)	937	0.98	(0.82,	1.18)	0.850	0.91	(0.76,	1.10)	0.343
Total	15,032	(30%)	35,347	(70%)	50,379								

Model One Adjustment Logistic Regression Results for 'Dental Health Support Worker Contacts'

Type 3 Results:	Chi-Square	Df	p-value	C-index
	75.38	3	<0.001	0.65

*Model One is the logistic regression adjusted by the Scottish Index of Multiple Deprivation Index (SIMD), sex, and age.

4.4.2.2 Association between the Number of Childsmile Contacts at a Dental Practice and Caries Experience

The results of the logistic regression of Caries Experience according to ‘Childsmile Dental Practice Contacts’ adjusted by SIMD, Sex, and Age are presented in Table 4-6. The variable ‘Childsmile Dental Practice Contacts’ has eleven categories: ‘0 Childsmile contacts’, ‘1 contact’ … ‘9 contacts’ and ‘10 plus contacts’. Children with ‘0 Childsmile contacts’ at a dental practice were the referent category selected in this analysis so that the odds of Caries Experience could be compared in relation to this as the number of contacts increased.

Compared to those children who had never attended a dental practice for Childsmile, with the exception of those who attended only once, the odds of Caries Experience reduced with increasing number of visits – with greater than two contacts becoming significant. Those attending ten or more times (two or more visits per year) experienced a 67% reduction in odds of Caries Experience (AOR = 0.33; 95% CI = [0.18 to 0.60]) compared with those who never attended.

Table 4-6: Logistic Regression of ‘Childsmile Dental Practice Contacts’ in Relation to Caries Experience: Unadjusted and Model One Adjustment*

Number of Contacts	Caries Experience n	%	No Caries Experience n	%	Total	Unadjusted OR	95% CI		p-value	Model One AOR	95% CI		p-value
0 Childsmile contacts	4,708	(32%)	10,134	(68%)	14,842	-	Referent		-	-	Referent		-
1 contact	3,699	(35%)	6,954	(65%)	10,653	1.14	(1.09,	1.21)	<0.001	1.12	(1.06,	1.18)	<0.001
2 contacts	2,620	(32%)	5,645	(68%)	8,265	1.00	(0.94,	1.06)	0.974	0.99	(0.94,	1.05)	0.813
3 contacts	1,676	(27%)	4,503	(73%)	6,179	0.80	(0.75,	0.86)	<0.001	0.82	(0.76,	0.87)	<0.001
4 contacts	1,080	(24%)	3,449	(76%)	4,529	0.67	(0.62,	0.73)	<0.001	0.71	(0.66,	0.77)	<0.001
5 contacts	669	(22%)	2,394	(78%)	3,063	0.60	(0.55,	0.66)	<0.001	0.64	(0.58,	0.71)	<0.001
6 contacts	327	(21%)	1,250	(79%)	1,577	0.56	(0.50,	0.64)	<0.001	0.58	(0.51,	0.66)	<0.001
7 contacts	138	(21%)	530	(79%)	668	0.56	(0.46,	0.68)	<0.001	0.55	(0.45,	0.66)	<0.001
8 contacts	73	(21%)	272	(79%)	345	0.58	(0.45,	0.75)	<0.001	0.54	(0.41,	0.70)	<0.001
9 contacts	29	(18%)	132	(82%)	161	0.47	(0.32,	0.71)	<0.001	0.40	(0.27,	0.61)	<0.001
10 plus contacts	13	(13%)	84	(87%)	97	0.33	(0.19,	0.60)	<0.001	0.33	(0.18,	0.60)	<0.001
Total	15,032	(30%)	35,347	(70%)	50,379								

Model One Logistic Regression Results of ‘Childsmile Dental Practice Contacts’

Type 3 Results:	Chi-Square	Df	p-value	C-index
	471.05	10	<0.001	0.66

*Model One is the logistic regression adjusted by the Scottish Index of Multiple Deprivation Index (SIMD), sex, and age

4.4.2.3 Association between Time Toothbrushing and Caries Experience

The results of the logistic regression of Caries Experience according to ‘Time Toothbrushing’, adjusted by SIMD, Sex, and Age are presented in Table 4-7. The variable has four categories: ‘0 (no consent)’, ‘Up to 1 year’, ‘1 to 2 years’ and ‘2 plus years’. Each category represents a year i.e. ‘Up to 1 year’ is one day to one year of toothbrushing consent prior to the NDIP inspection date. Children that were not toothbrushing, ‘0 (no consent)’, were the referent category chosen in this analysis so that the odds of Caries Experience could be compared in relation to this as the time toothbrushing increased.

There was a slight does response effect with ‘Time toothbrushing’, whereby the prevalence of Caries Experience reduced as the length of time toothbrushing increased from 36% for those children with less than one year of toothbrushing to 29% for those with more than two years of toothbrushing.

Compared to those who were not consented to toothbrushing, those who had brushed for two or more years had lower odds of Caries Experience (AOR = 0.81; 95% CI = [0.76 to 0.87]). Although Caries Experience was less likely for those children that had only brushed for up to one year, the confidence interval overlapped 1, suggesting insufficient evidence for a difference.

Table 4-7: Logistic Regression of 'Time Toothbrushing' in Relation to Caries Experience: Unadjusted and Model One* Adjustment

Time Consented	Caries Experience n	%	No Caries Experience N	%	Total	Unadjusted OR	95% CI		p-value	Model One AOR	95% CI		p-value
0 (no consent)	1,572	(29%)	3,939	(72%)	5,511	-	Referent		-	-	Referent		-
Up to 1 year	1,269	(36%)	2,296	(64%)	3,565	1.38	(1.27,	1.52)	<0.001	1.01	(0.92,	1.11)	0.829
>1 to 2 years	3,990	(32%)	8,589	(68%)	12,579	1.16	(1.09,	1.25)	<0.001	0.93	(0.87,	1.01)	0.069
>2 years	8,201	(29%)	20,523	(71%)	28,724	1.00	(0.94,	1.07)	0.968	0.81	(0.76,	0.87)	<0.001
Total	15,032	(30%)	35,347	(70%)	50,379								

Model One Logistic Regression Results for 'Time Toothbrushing'

Type 3 Results:	Chi-Square	D	p-value	C-index
	77.42	3	<0.001	0.65

*Model One is the logistic regression adjusted by the Scottish Index of Multiple Deprivation Index (SIMD), sex, and age.

4.4.2.4 Association between the Number of Nursery and School Fluoride Varnish Applications and Caries Experience

Table 4-8 presents the results of the logistic regression of Caries Experience according to ‘Nursery and School Fluoride Varnish Applications’ adjusted by SIMD, Sex, and Age. The variable ‘Nursery and School Fluoride Varnish Applications’ has seven categories: ‘Not Targeted’, ‘0 applications’, ‘1 application’, ‘2 applications’, ‘3 applications’, ‘4 applications’ and ‘5 plus applications’. Children that were targeted for a fluoride varnish application at either nursery or school and did not it receive it (i.e. ‘0 applications’) were the referent category chosen in this analysis so that the odds of Caries Experience could be compared in relation to this as the number of fluoride varnish applications increased.

For children that were targeted for a fluoride varnish application, the prevalence of Caries Experience was very similar for those children that did not receive it (32%) in comparison to those who received five (33%).

After adjustment for the three potential confounders, children that were not targeted for a fluoride varnish application were less likely to have Caries Experience than those that were targeted (AOR = 0.80; 95% CI = [0.75 to 0.85]). For children that were targeted, the odds of Caries Experience decreased with increasing number of fluoride varnish applications (‘5 plus applications’ AOR = 0.86; 95% CI = [0.79 to 0.93]) and was only significant with four or more applications.

Table 4-8: Logistic Regression of 'Nursery and School Fluoride Varnish Applications' in Relation to Caries Experience: Unadjusted and Model One Adjustment*

Number of Applications	Caries Experience n	%	No Caries Experience n	%	Total	Unadjusted OR	95% CI		p-value	Model One AOR	95% CI		p-value
Not Targeted	4,306	(23%)	14,492	(77%)	18,798	0.63	(0.59,	0.67)	<0.001	0.80	(0.75,	0.85)	<0.001
0 applications	2,233	(32%)	4,735	(68%)	6,968	-	Referent		-	-	Referent		-
1 application	1,676	(35%)	3,094	(65%)	4,770	1.15	(1.06,	1.24)	<0.001	0.98	(0.90,	1.06)	0.575
2 applications	1,676	(36%)	3,006	(64%)	4,682	1.18	(1.09,	1.28)	<0.001	1.03	(0.95,	1.12)	0.468
3 applications	1,844	(35%)	3,479	(65%)	5,323	1.12	(1.04,	1.21)	0.002	0.95	(0.87,	1.02)	0.156
4 applications	1,843	(34%)	3,640	(66%)	5,483	1.07	(1.00,	1.16)	0.064	0.89	(0.82,	0.96)	0.003
5 plus applications	1,454	(33%)	2,901	(67%)	4,355	1.06	(0.98,	1.15)	0.139	0.86	(0.79,	0.93)	<0.001
Total	15,032	(30%)	35,347	(70%)	50,379								

Model One Logistic Regression Results for 'Nursery and School Fluoride Varnish Applications'

Type 3 Results:	Chi-Square	Df	p-value	C-index
	82.28	6	<0.001	0.65

*Model One is the logistic regression adjusted by the Scottish Index of Multiple Deprivation Index (SIMD), sex, and age.

4.4.3 Exploring the modifying effect of SIMD on the relationship between Caries Experience and the Childsmile Components

Interactions between Childsmile components and SIMD, Sex, and Age were tested (Table 4-9). There were statistically significant interactions between Time Toothbrushing and SIMD ($p < 0.001$) and Nursery and School Fluoride Varnish Applications and SIMD ($p = 0.014$).

Table 4-9: Interaction Test of SIMD, Sex and Age with Childsmile Components

Component	SIMD P-Type 3	Sex P-Type 3	Age P-Type 3
Dental Health Support Worker Contacts	0.654	0.578	0.069
Childsmile Dental Practice Contacts	0.549	0.424	0.659
Time Toothbrushing	<0.001	0.943	0.108
Nursery and School Fluoride Varnish Applications	0.014	0.239	0.276

4.4.4 Association between Childsmile Components and Caries Experience by Area-based Deprivation (SIMD)

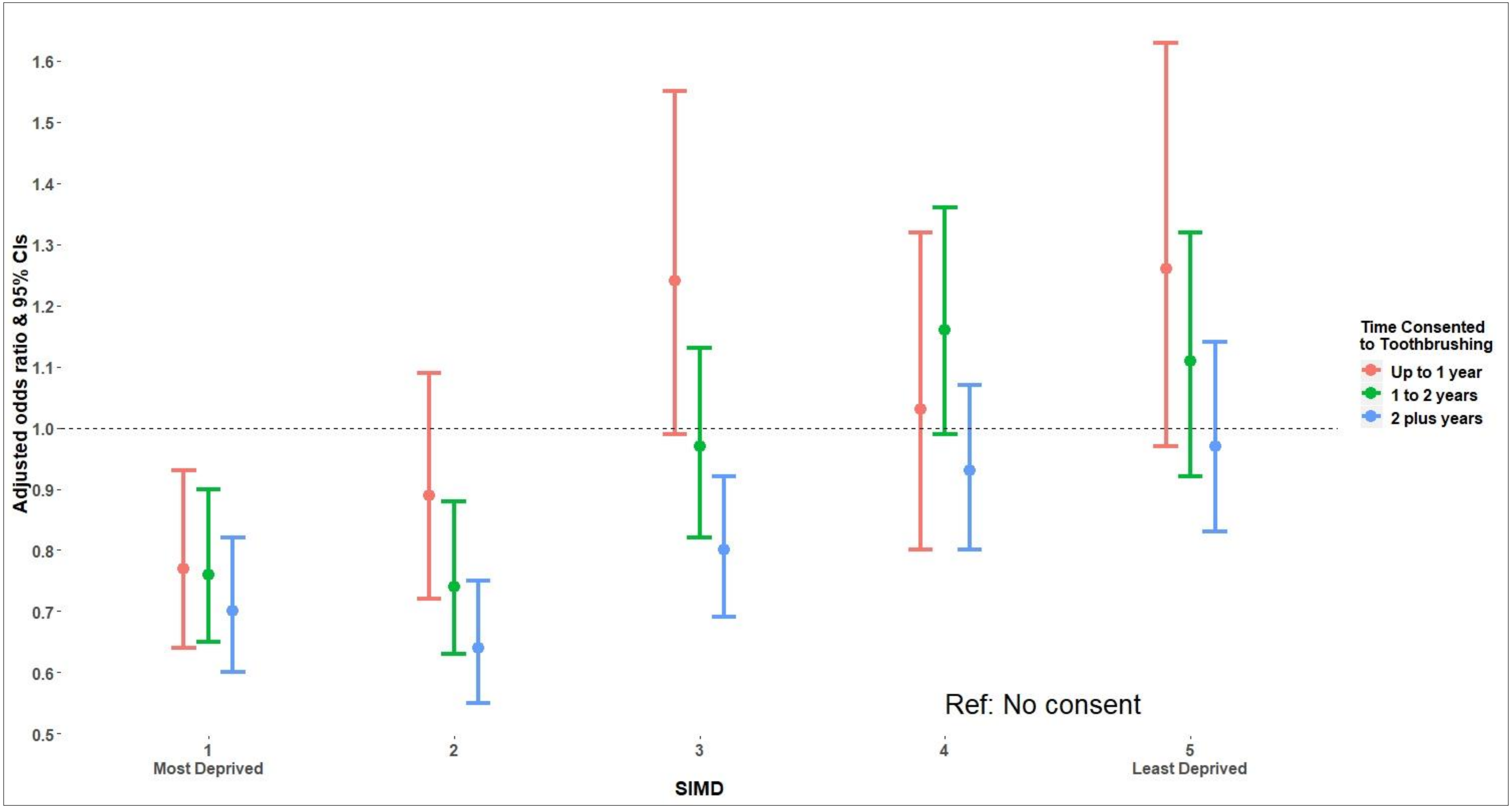
4.4.4.1 Association between Time Toothbrushing and Caries Experience by Area-based Deprivation (SIMD)

The interaction between SIMD and Time Toothbrushing on Caries Experience, suggests a modifying effect of SIMD on the association between Time Toothbrushing and Caries Experience. The following section sets out to explain this finding, by examining the Time Toothbrushing-Caries Experience association within each SIMD category.

For children living in the 20% most deprived areas of Scotland (SIMD 1) there was a reduction in the odds of Caries Experience for those children that had only been toothbrushing for one year (SIMD 1 AOR = 0.77; 95% CI = [0.64 to 0.93]) compared to those that had never been consented to toothbrushing, and with each additional year of Time Toothbrushing, the odds of Caries Experience reduced further (Figure 4-8 and Table 4-10). A similar but not so marked effect (AOR = 0.89; 95% CI = [0.72 to 1.09]) was observed for children living in SIMD 2 areas. The benefits of ‘any’ toothbrushing were less clear for children in less deprived areas (SIMD 3,4,5), although it should be noted the relatively smaller numbers of children toothbrushing for less than a year in the more affluent groups (SIMD 3,4,5) (Table 4-10).

Overall, the results indicate that Time Toothbrushing was having the greatest impact in the two most deprived areas (SIMD 1 and SIMD 2) and is clearly beneficial even with only one year of toothbrushing. This variation in the effect of Time Toothbrushing by deprivation category is very clear in the visual presentation of Figure 4-8, where an obvious ‘dose response’ is evident.

Figure 4-8: Model One Odds Ratios and 95% Confidence Intervals of 'Time Consented to Toothbrushing' in Relation to Caries Experience by SIMD



Model One is the logistic regression adjusted by sex and age; SIMD – Scottish Index of Multiple Deprivation.

Table 4-10: Logistic Regression of 'Time Toothbrushing' in Relation to Caries Experience by SIMD: Unadjusted and Model One Adjustment*

SIMD	Time Consented	Caries Experience n	%	No Caries Experience n	%	Total	Unadjusted OR	95% CI		p-value	Model One AOR	95% CI		p-value
1 (Most Deprived)	**0 (no consent)**	353	(52%)	321	(48%)	674	-	Referent		-	-	Referent		-
	Up to 1 year	585	(46%)	694	(54%)	1,279	0.77	(0.64,	0.92)	0.005	0.77	(0.64,	0.93)	0.007
	>1 to 2 years	1,565	(45%)	1,908	(55%)	3,473	0.75	(0.63,	0.88)	<0.001	0.76	(0.65,	0.90)	0.001
	>2 years	2,807	(44%)	3,544	(56%)	6,351	0.72	(0.61,	0.84)	<0.001	0.70	(0.60,	0.82)	<0.001
	Total	5,310	(45%)	6,467	(55%)	11,777								
2	**0 (no consent)**	338	(43%)	441	(57%)	779	-	Referent		-	-	Referent		-
	Up to 1 year	301	(40%)	449	(60%)	750	0.87	(0.71,	1.07)	0.197	0.89	(0.72,	1.09)	0.259
	>1 to 2 years	934	(36%)	1,685	(64%)	2,619	0.72	(0.61,	0.85)	<0.001	0.74	(0.63,	0.88)	<0.001
	>2 years	1,976	(33%)	3,968	(67%)	5,944	0.65	(0.56,	0.76)	<0.001	0.64	(0.55,	0.75)	<0.001
	Total	3,549	(35%)	6,543	(65%)	10,092								
3	**0 (no consent)**	333	(30%)	779	(70%)	1,112	-	Referent		-	-	Referent		-
	Up to 1 year	180	(34%)	356	(66%)	536	1.18	(0.95,	1.47)	0.135	1.24	(0.99,	1.55)	0.057
	>1 to 2 years	612	(28%)	1,586	(72%)	2,198	0.90	(0.77,	1.06)	0.206	0.97	(0.82,	1.13)	0.667
	>2 years	1,472	(26%)	4,291	(75%)	5,763	0.80	(0.70,	0.92)	0.002	0.80	(0.69,	0.92)	0.002
	Total	2,597	(27%)	7,012	(37%)	9,609								

4	**0 (no consent)**	306	(22%)	1,081	(78%)	1,387	-	Referent		-	-	Referent		-
	Up to 1 year	106	(22%)	372	(78%)	478	1.01	(0.78,	1.29)	0.959	1.03	(0.80,	1.32)	0.818
	>1 to 2 years	538	(24%)	1,699	(76%)	2,237	1.12	(0.95,	1.31)	0.169	1.16	(0.99,	1.36)	0.072
	>2 years	1,204	(21%)	4,570	(79%)	5,774	0.93	(0.81,	1.07)	0.321	0.93	(0.80,	1.07)	0.297
	Total	2,154	(22%)	7,722	(78%)	9,876								
5 (Least Deprived)	**0 (no consent)**	242	(16%)	1,317	(85%)	1,559	-	Referent		-	-	Referent		-
	Up to 1 year	97	(19%)	425	(81%)	522	1.24	(0.96,	1.61)	0.102	1.26	(0.97,	1.63)	0.082
	>1 to 2 years	341	(17%)	1,711	(83%)	2,052	1.08	(0.91,	1.30)	0.376	1.11	(0.92,	1.32)	0.274
	>2 years	742	(15%)	4,150	(85%)	4,892	0.97	(0.83,	1.14)	0.734	0.97	(0.83,	1.14)	0.729
	Total	1,422	(16%)	7,603	(84%)	9,025								

*Model One is the logistic regression adjusted by sex and age; SIMD – Scottish Index of Multiple Deprivation.

4.4.4.2 Association between the Number of Nursery and School Fluoride Varnish Applications and Caries Experience by Area Based-Deprivation (SIMD)

The interaction test in Section 4.4.3 indicated that the effect of ‘Nursery and School Fluoride Varnish Applications’ on Caries Experience was modified in some way by SIMD, therefore the unadjusted odds ratios and Model One odds ratios (adjusted by sex and age) were partitioned by SIMD quintile and reported in Figure 4-9 and Table 4-11. The same categories are used as in Section 4.4.2.4.

Children that were not targeted for a fluoride varnish application at nursery or school had lower odds of Caries Experience than those that were targeted but not receiving a fluoride varnish application. This was consistent across all SIMD groups.

For those children that were targeted in SIMD 1 (the 20% most deprived area), there was a small trend in the reduction in odds of Caries Experience observed as the number of fluoride varnish applications increased.

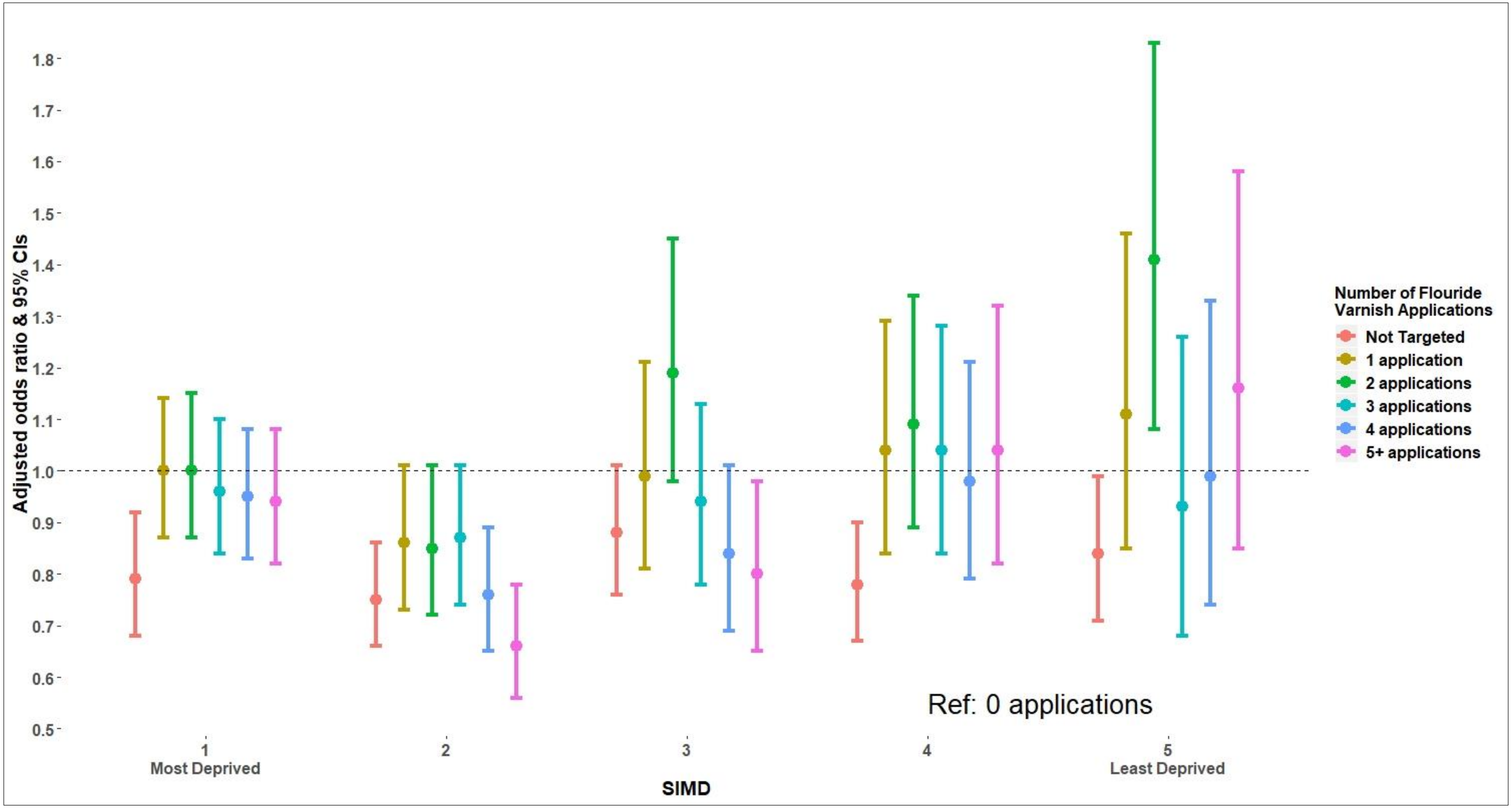
In SIMD 2, there was a gradient in the reduction of the odds of Caries Experience as the number of fluoride varnish applications increased for children that were targeted. Children who received five or more applications were 34% less likely to have Caries Experience than those targeted and not receiving it (AOR = 0.66; 95% = [CI 0.56 to 0.78]). Children from SIMD 2 had to have received four fluoride varnish applications before they had the similar reduction in the odds of Caries Experience (AOR = 0.76; 95% CI = [0.65 to 0.89]) as those children that had not been targeted.

For SIMD 3, there was no reduction in the odds of Caries Experience until a child had received four fluoride varnish applications with the odds decreasing further with five or more fluoride varnish applications (AOR = 0.80; 95% CI = [0.65 to 0.98]). Similar to SIMD 2, a child required four fluoride varnish applications for the odds to have reduced to below that of a child that had not been targeted (AOR = 0.84; 95% CI = [0.69 to 1.01]).

In both SIMD 4 and SIMD 5 (the 20% least deprived areas), for children that were targeted for toothbrushing, there was no pattern of change observed in the odds of Caries Experience regardless of the number of fluoride varnish applications a child received. It should be noted that the frequencies of fluoride varnish applications were lower as the level of deprivation decreased due to this component being targeted to nurseries and schools with the highest proportion of children living within the 20% most deprived areas within each health board area.

Overall, while there is a tendency for lower odds of Caries Experience in SIMD 1 and SIMD 2 as the number of fluoride varnish applications increase, these reductions do not reach significant levels in children in SIMD 1, and only in SIMD 2 at a high number of applications.

Figure 4-9: Model One Odds Ratios and 95% Confidence Intervals of 'Nursery and School Fluoride Varnish Applications' in Relation to Caries Experience by SIMD



Model One is the logistic regression adjusted by sex and age; SIMD – Scottish Index of Multiple Deprivation.

Table 4-11: Logistic Regression of 'Nursery and School Fluoride Varnish Applications' in Relation to Caries Experience by SIMD: Unadjusted and Model One Adjustment*

SIMD	Number of Applications	Caries Experience n	%	No Caries Experience n	%	Total	OR	Unadjusted 95% CI		p-value	AOR	Model One 95% CI		p-value
1	**Not Targeted**	503	(41%)	739	(60%)	1,242	0.80	(0.69,	0.93)	0.003	0.79	(0.68,	0.92)	0.002
	0 applications	771	(46%)	905	(54%)	1,676	-	Referent		-	-	Referent		-
	1 application	821	(46%)	963	(54%)	1,784	1.00	(0.88,	1.14)	0.992	1.00	(0.87,	1.14)	0.979
	2 applications	780	(46%)	914	(54%)	1,694	1.00	(0.87,	1.15)	0.980	1.00	(0.87,	1.15)	0.998
	3 applications	865	(45%)	1,054	(55%)	1,919	0.96	(0.84,	1.10)	0.578	0.96	(0.84,	1.10)	0.542
	4 applications	881	(45%)	1,069	(55%)	1,950	0.97	(0.85,	1.10)	0.620	0.95	(0.83,	1.08)	0.429
	5 plus applications	689	(46%)	823	(54%)	1,512	0.98	(0.85,	1.13)	0.806	0.94	(0.82,	1.08)	0.396
	Total	5,310	(45%)	6,467	(55%)	11,777								
2	**Not Targeted**	939	(34%)	1,867	(67%)	2,806	0.75	(0.66,	0.86)	<0.001	0.75	(0.66,	0.86)	<0.001
	0 applications	571	(40%)	856	(60%)	1,427	-	Referent		-	-	Referent		-
	1 application	386	(36%)	676	(64%)	1,062	0.86	(0.73,	1.01)	0.063	0.86	(0.73,	1.01)	0.065
	2 applications	343	(36%)	603	(64%)	946	0.85	(0.72,	1.01)	0.066	0.85	(0.72,	1.01)	0.060
	3 applications	473	(37%)	819	(63%)	1,292	0.87	(0.74,	1.01)	0.068	0.87	(0.74,	1.01)	0.075
	4 applications	472	(34%)	923	(66%)	1,395	0.77	(0.66,	0.89)	<0.001	0.76	(0.65,	0.89)	<0.001
	5 plus applications	365	(31%)	799	(69%)	1,164	0.68	(0.58,	0.81)	<0.001	0.66	(0.56,	0.78)	<0.001
	Total	3,549	(35%)	6,543	(65%)	10,092								

3	**Not Targeted**	1,065	(26%)	3,017	(74%)	4,082	0.88	(0.77,	1.01)	0.069	0.88	(0.76,	1.01)	0.065
	0 applications	373	(29%)	929	(71%)	1,302	-	Referent		-	-	Referent		-
	1 application	213	(28%)	540	(72%)	753	0.98	(0.81,	1.20)	0.861	0.99	(0.81,	1.21)	0.956
	2 applications	242	(32%)	511	(68%)	753	1.18	(0.97,	1.43)	0.096	1.19	(0.98,	1.45)	0.080
	3 applications	255	(27%)	685	(73%)	940	0.93	(0.77,	1.12)	0.429	0.94	(0.78,	1.13)	0.497
	4 applications	245	(25%)	723	(75%)	968	0.84	(0.70,	1.02)	0.077	0.84	(0.69,	1.01)	0.062
	5 plus applications	204	(25%)	607	(75%)	811	0.84	(0.69,	1.02)	0.080	0.80	(0.65,	0.98)	0.029
	Total	2,597	(27%)	7,012	(37%)	9,609								
4	**Not Targeted**	979	(20%)	4,041	(81%)	5,020	0.78	(0.68,	0.91)	0.001	0.78	(0.67,	0.90)	<0.001
	0 applications	302	(24%)	976	(76%)	1,278	-	Referent		-	-	Referent		-
	1 application	168	(24%)	523	(76%)	691	1.04	(0.84,	1.29)	0.735	1.04	(0.84,	1.29)	0.737
	2 applications	207	(25%)	610	(75%)	817	1.10	(0.89,	1.34)	0.374	1.09	(0.89,	1.34)	0.397
	3 applications	189	(24%)	587	(76%)	776	1.04	(0.84,	1.28)	0.709	1.04	(0.84,	1.28)	0.722
	4 applications	176	(23%)	579	(77%)	755	0.98	(0.79,	1.21)	0.870	0.98	(0.79,	1.21)	0.838
	5 plus applications	133	(25%)	406	(75%)	539	1.06	(0.84,	1.34)	0.634	1.04	(0.82,	1.32)	0.740
	Total	2,154	(22%)	7,722	(78%)	9,876								

5	**Not Targeted**	820	(15%)	4,828	(86%)	5,648	0.84	(0.71,	0.99)	0.038	0.84	(0.71,	0.99)	0.036
	0 applications	216	(17%)	1,069	(83%)	1,285	-	Referent		-	-	Referent		-
	1 application	88	(18%)	392	(82%)	480	1.11	(0.85,	1.46)	0.451	1.11	(0.85,	1.46)	0.445
	2 applications	104	(22%)	368	(78%)	472	1.40	(1.08,	1.82)	0.012	1.41	(1.08,	1.83)	0.011
	3 applications	62	(16%)	334	(84%)	396	0.92	(0.68,	1.25)	0.589	0.93	(0.68,	1.26)	0.620
	4 applications	69	(17%)	346	(83%)	415	0.99	(0.73,	1.33)	0.931	0.99	(0.74,	1.33)	0.950
	5 plus applications	63	(19%)	266	(81%)	329	1.17	(0.86,	1.60)	0.317	1.16	(0.85,	1.58)	0.356
	Total	1,422	(16%)	7,603	(84%)	9,025								

*Model One is the logistic regression adjusted by sex and age; SIMD – Scottish Index of Multiple Deprivation.

4.4.5 Independent Effects of the Childsmile Components on Caries Experience (Model Two)

The previous sections have presented the individual impacts of the Childsmile components after adjustment for potential confounders. The following sections now consider which Childsmile components independently impact on Caries Experience by including all components simultaneously within a multivariable model (Model Two).

4.4.5.1 Independent effect of 'Dental Health Support Worker Contacts' on Caries Experience (Model Two)

The effect of DHSW contacts on Caries Experience after adjustment for all the other Childsmile components attenuated slightly but did not change the overall results indicating that DHSW contacts are independently associated with Caries Experience (Table 4-12). Children with one DHSW contact had 31% lower odds of Caries Experience (AOR = 0.69; 95% CI = [0.60 to 0.79]) than children targeted but not contacted.

Table 4-12: Logistic Regression of ‘Dental Health Support Worker Contacts’ in Relation to Caries Experience: Model One* and Model Two Adjustments**

Number of Contacts	Caries Experience n	%	No Caries Experience n	%	Total	Model One AOR	Model One 95% CI	Model One p-value	Model Two AOR	Model Two 95% CI	Model Two p-value
Not Targeted	11,547	(28%)	29,100	(72%)	40,647	0.63	(0.55, 0.72)	<0.001	0.65	(0.57, 0.74)	<0.001
0 contacts	442	(45%)	537	(55%)	979	-	Referent	-	-	Referent	-
1 contact	2,624	(34%)	5,192	(66%)	7,816	0.63	(0.54, 0.72)	<0.001	0.69	(0.60, 0.79)	<0.001
2 plus contacts	419	(45%)	518	(55%)	937	0.91	(0.76, 1.10)	0.343	0.94	(0.78, 1.14)	0.534
Total	15,032	(30%)	35,347	(70%)	50,379						

Model Two Logistic Regression Results for ‘Dental Health Support Worker Contacts’

Type 3 Results:	Chi-Square	Df	p-value	C-index
	69.15	3	<0.001	0.66

*Model One is the logistic regression adjusted by the Scottish Index of Multiple Deprivation Index (SIMD), sex, and age; **Model Two is the logistic regression adjusted by SIMD, sex, age, the three other Childsmile Components (Childsmile Dental Practice Contacts, Time Toothbrushing and Nursery and School Fluoride Varnish Applications) and the interactions between Time Toothbrushing and SIMD, and Nursery and School Fluoride Varnish Applications and SIMD.

4.4.5.2 Independent effect of 'Childsmile Dental Practice Contacts' on Caries Experience (Model Two)

There was no change in the effect of Childsmile contacts at a dental practice after adjustment for all other Childsmile components (Table 4-13). Therefore, this component was independently associated with Caries Experience. Children with five contacts had a 35% reduction in odds of Caries Experience (AOR = 0.65; 95% CI = [0.59 to 0.72]) and children with ten contacts had a 67% odds reduction (AOR = 0.33; 95% CI = [0.18 to 0.60]) in comparison to children with no contacts.

Table 4-13: Logistic Regression of 'Childsmile Dental Practice Contacts' in Relation to Caries Experience: Model One* and Model Two Adjustments**

Contacts	Caries Experience n	%	No Caries Experience n	%	Total	Model One AOR	Model One 95% CI		Model One p-value	Model Two AOR	Model Two 95% CI		Model Two p-value
0	4,708	(32%)	10,134	(68%)	14,842	-	Referent		-	-	Referent		-
1	3,699	(35%)	6,954	(65%)	10,653	1.12	(1.06,	1.18)	<0.001	1.12	(1.06,	1.18)	<0.001
2	2,620	(32%)	5,645	(68%)	8,265	0.99	(0.94,	1.05)	0.813	1.00	(0.94,	1.06)	0.976
3	1,676	(27%)	4,503	(73%)	6,179	0.82	(0.76,	0.87)	<0.001	0.83	(0.77,	0.89)	<0.001
4	1,080	(24%)	3,449	(76%)	4,529	0.71	(0.66,	0.77)	<0.001	0.73	(0.67,	0.79)	<0.001
5	669	(22%)	2,394	(78%)	3,063	0.64	(0.58,	0.71)	<0.001	0.65	(0.59,	0.72)	<0.001
6	327	(21%)	1,250	(79%)	1,577	0.58	(0.51,	0.66)	<0.001	0.59	(0.52,	0.67)	<0.001
7	138	(21%)	530	(79%)	668	0.55	(0.45,	0.66)	<0.001	0.55	(0.45,	0.67)	<0.001
8	73	(21%)	272	(79%)	345	0.54	(0.41,	0.70)	<0.001	0.53	(0.41,	0.69)	<0.001
9	29	(18%)	132	(82%)	161	0.40	(0.27,	0.61)	<0.001	0.40	(0.27,	0.61)	<0.001
10 plus	13	(13%)	84	(87%)	97	0.33	(0.18,	0.60)	<0.001	0.33	(0.18,	0.60)	<0.001
Total	15,032	(30%)	35,347	(70%)	50,379								

Model Two Logistic Regression Results for 'Childsmile Dental Practice Contacts'

Type 3 Results:	Chi-Square	Df	p-value	C-index
	342.96	10	<0.001	0.66

*Model One is the logistic regression adjusted by the Scottish Index of Multiple Deprivation Index (SIMD), sex, and age; **Model Two is the logistic regression adjusted by SIMD, sex, age, the three other Childsmile Components (Dental Health Support Worker Contacts, Time Toothbrushing and Nursery and School Fluoride Varnish Applications) and the interactions between Time Toothbrushing and SIMD, and Nursery and School Fluoride Varnish Applications and SIMD.

4.4.5.3 Independent effect of 'Time Toothbrushing' on Caries Experience (Model Two)

As there was an interaction between the variable 'Time Toothbrushing' and SIMD on Caries Experience, the Model One odds ratios (adjusted by sex and age) and Model Two odds ratios (adjusted by sex, age, and the other Childsmile components) were partitioned by SIMD quintiles and reported in Table 4-15 and Figure 4-10. The unpartitioned adjusted odds ratios are presented for reference (Table 4-14).

For children living in SIMD 1 (the 20% most deprived areas) and SIMD 2, there remained a reduction in the odds of Caries Experience for those children that had been in the toothbrushing programme for up to one year (SIMD 1 AOR = 0.67; 95% CI = [0.55 to 0.82]) and SIMD 2 AOR = 0.83; 95% CI = [0.66 to 1.03]) compared to those that had never been in the toothbrushing programme. The odds of Caries Experience continued to decrease in both SIMD 1 and 2 as the length of toothbrushing time increased. For children that had brushed for more than two years, there was a 38% reduction in the odds of Caries Experience for children in SIMD 1 (AOR = 0.62; 95% CI = [0.52 to 0.75]) and a 36% reduction in SIMD2 (AOR = 0.64; 95% CI = [0.54 to 0.76]).

For children in SIMD 3, there remained a reduction in the odds of Caries Experience for children when they had been in the toothbrushing programme for more than two years (AOR = 0.79; 95% CI = [0.67 to 0.92]) compared to those that had never been in the toothbrushing programme. Although children with only one year of supervised toothbrushing had increased odds of Caries Experience (AOR = 1.14; 95% CI = [0.90 to 1.44]), this was not statistically significant.

Children living in SIMD 4 that had been in the toothbrushing programme for more than two years had reduced odds of Caries Experience compared to those children who had not been in it (AOR = 0.81; 95% CI = [0.69 to 0.94]). In children from SIMD 5 (the 20% least deprived areas), however, there remained no significant increases or decreases of odds of Caries Experience regardless of the length of time the child had been in toothbrushing programme.

Overall, the results indicate that toothbrushing continued to have its greatest impact within both SIMD 1 and 2 and that there was a minimal strengthening on the effect of toothbrushing (although this was strongest in SIMD 1) and therefore it remained independently associated with Caries Experience.

Table 4-14: Logistic Regression of 'Time Toothbrushing' in Relation to Caries Experience: Model One* and Model Two Adjustments**

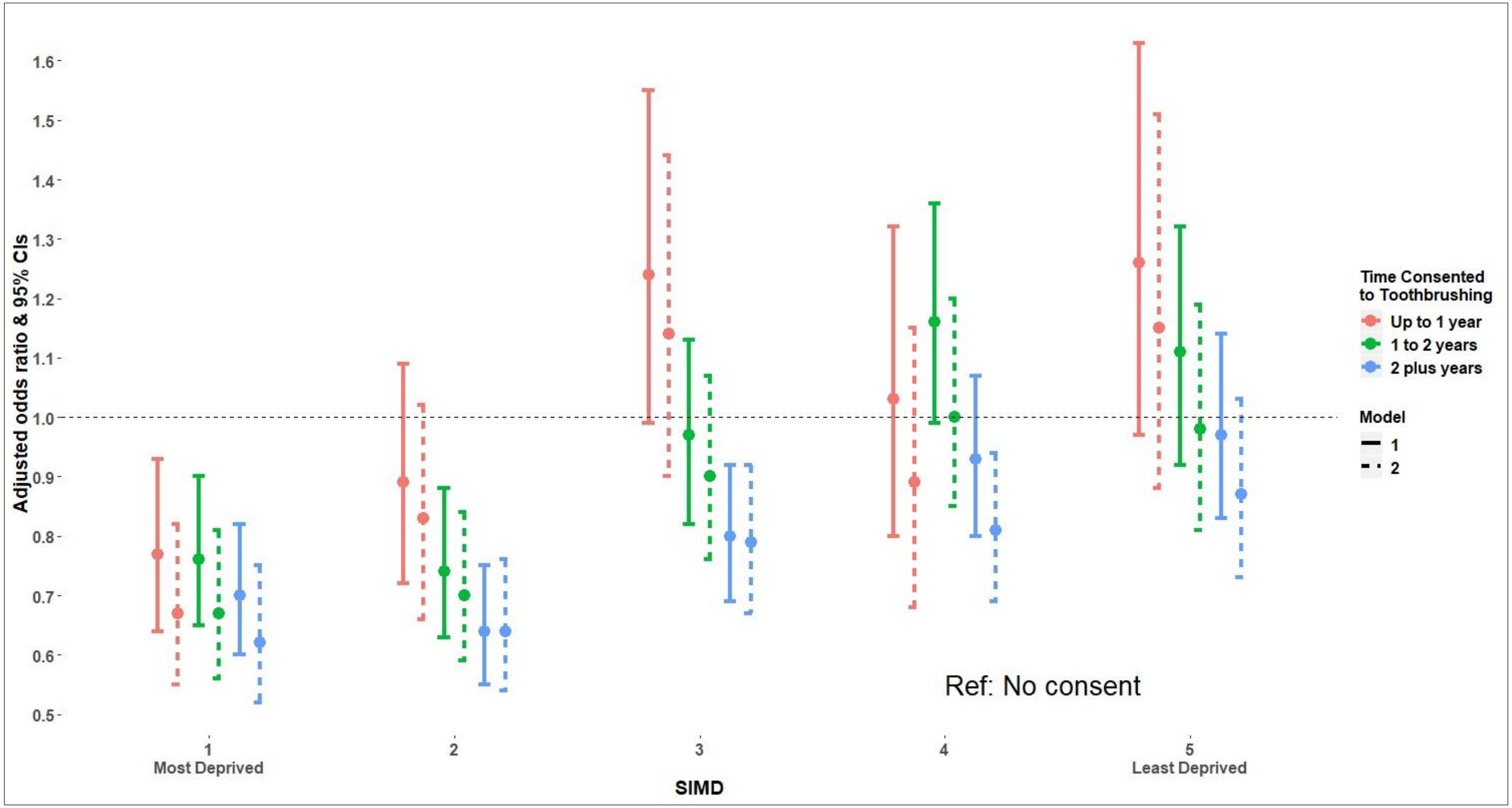
						Model One				Model Two		
Time Consented	**Caries Experience** n	%	**No Caries Experience** n	%	**Total**	**AOR**	**95% CI**	**p-value**	**AOR**	**95% CI**	**p-value**
0 (no consent)	1,572	(29%)	3,939	(72%)	5,511	-	Referent	-	-	Referent	-
Up to 1 year	1,269	(36%)	2,296	(64%)	3,565	1.01	(0.92, 1.11)	0.829	0.90	(0.82, 1.00)	0.045
>1 to 2 years	3,990	(32%)	8,589	(68%)	12,579	0.93	(0.87, 1.01)	0.069	0.85	(0.79, 0.92)	<0.001
>2 years	8,201	(29%)	20,523	(71%)	28,724	0.81	(0.76, 0.87)	<0.001	0.75	(0.70, 0.81)	<0.001
Total	15,032	(30%)	35,347	(70%)	50,379						

Model Two Logistic Regression Results for 'Time Toothbrushing'

Type 3 Results:	**Chi-Square**	**Df**	**p-value**	**C-index**
	74.53	3	<0.001	0.66

*Model One is the logistic regression adjusted by the Scottish Index of Multiple Deprivation Index (SIMD), sex, and age; **Model Two is the logistic regression adjusted by SIMD, sex, age, the three other Childsmile Components (Dental Health Support Worker Contacts, Childsmile Dental Practice Contacts, and Nursery and School Fluoride Varnish Applications).

Figure 4-10: Model One* and Model Two Odds Ratios and 95% Confidence Intervals of 'Time Toothbrushing' in Relation to Caries Experience by SIMD**



*Model One is the logistic regression adjusted by the Scottish Index of Multiple Deprivation Index (SIMD), sex, and age; **Model Two is the logistic regression adjusted by sex, age, the three other Childsmile Components (Dental Health Support Worker Contacts, Childsmile Dental Practice Contacts, and Nursery and School Fluoride Varnish Applications).

Table 4-15: Logistic Regression of 'Time Toothbrushing' in Relation to Caries Experience by SIMD: Model One* and Model Two Adjustments**

SIMD	Time Toothbrushing	Caries Experience n	%	No Caries Experience n	%	Total	Model One AOR	95% CI		p-value	Model Two AOR	95% CI		p-value
1	**0 (no consent)**	353	(52%)	321	(48%)	674	-	Referent		-	-	Referent		-
	Up to 1 year	585	(46%)	694	(54%)	1279	0.77	(0.64,	0.93)	0.007	0.67	(0.55,	0.82)	<0.001
	>1 to 2 years	1565	(45%)	1908	(55%)	3473	0.76	(0.65,	0.90)	0.001	0.67	(0.56,	0.81)	<0.001
	>2 years	2807	(44%)	3544	(56%)	6351	0.70	(0.60,	0.82)	<0.001	0.62	(0.52,	0.75)	<0.001
	Total	5310	(45%)	6467	(55%)	11777								
2	**0 (no consent)**	338	(43%)	441	(57%)	779	-	Referent		-	-	Referent		-
	Up to 1 year	301	(40%)	449	(60%)	750	0.89	(0.72,	1.09)	0.259	0.83	(0.66,	1.02)	0.084
	>1 to 2 years	934	(36%)	1685	(64%)	2619	0.74	(0.63,	0.88)	<0.001	0.70	(0.59,	0.84)	<0.001
	>2 years	1976	(33%)	3968	(67%)	5944	0.64	(0.55,	0.75)	<0.001	0.64	(0.54,	0.76)	<0.001
	Total	3549	(35%)	6543	(65%)	10092								
3	**0 (no consent)**	333	(30%)	779	(70%)	1112	-	Referent		-	-	Referent		-
	Up to 1 year	180	(34%)	356	(66%)	536	1.24	(0.99,	1.55)	0.057	1.14	(0.90,	1.44)	0.270
	>1 to 2 years	612	(28%)	1586	(72%)	2198	0.97	(0.82,	1.13)	0.667	0.90	(0.76,	1.07)	0.233
	>2 years	1472	(26%)	4291	(75%)	5763	0.80	(0.69,	0.92)	0.002	0.79	(0.67,	0.92)	0.002
	Total	2597	(27%)	7012	(37%)	9609								

4	**0 (no consent)**	306	(22%)	1081	(78%)	1387	-	Referent		-	-	Referent		-
	Up to 1 year	106	(22%)	372	(78%)	478	1.03	(0.80,	1.32)	0.818	0.89	(0.68,	1.15)	0.367
	>1 to 2 years	538	(24%)	1699	(76%)	2237	1.16	(0.99,	1.36)	0.072	1.01	(0.85,	1.20)	0.923
	>2 years	1204	(21%)	4570	(79%)	5774	0.93	(0.80,	1.07)	0.297	0.81	(0.69,	0.94)	0.006
	Total	2154	(22%)	7722	(78%)	9876								
5	**0 (no consent)**	242	(16%)	1317	(85%)	1559	-	Referent		-	-	Referent		-
	Up to 1 year	97	(19%)	425	(81%)	522	1.26	(0.97,	1.63)	0.082	1.15	(0.88,	1.51)	0.298
	>1 to 2 years	341	(17%)	1711	(83%)	2052	1.11	(0.92,	1.32)	0.274	0.98	(0.81,	1.19)	0.853
	>2 years	742	(15%)	4150	(85%)	4892	0.97	(0.83,	1.14)	0.729	0.87	(0.73,	1.03)	0.100
	Total	1422	(16%)	7603	(84%)	9025								

*Model One is the logistic regression adjusted by the Scottish Index of Multiple Deprivation Index (SIMD), sex and age; **Model Two is the logistic regression adjusted by sex, age, the three other Childsmile Components (Dental Health Support Worker Contacts, Childsmile Dental Practice Contacts, and Nursery and School Fluoride Varnish Applications).

4.4.5.4 Independent effect of 'Nursery and School Fluoride Varnish Applications' on Caries Experience (Model Two)

As there was an interaction between the variable 'Nursery and School Fluoride Varnish Applications' and SIMD, the Model One odds ratios (adjusted by sex and age) and Model Two odds ratios (adjusted by sex, age and the other Childsmile components) were partitioned by SIMD and reported in Table 4-17 and Figure 4-11. The unpartitioned adjusted odds ratios are presented for reference (Table 4-16).

In each SIMD category, children that were not targeted for a fluoride varnish application at nursery or school had lower odds of Caries Experience then those targeted but not receiving a fluoride varnish application.

In SIMD 1 (the 20% most deprived areas) there was no statistical strengthening or weakening of the effect of fluoride varnish application on Caries Experience as the number of fluoride varnish applications increased for those children that were targeted.

In SIMD 2, children receiving five or more applications were 20% less likely to have Caries Experience (AOR = 0.80; 95% CI = [0.67 to 0.95]), than those targeted and not receiving any.

In SIMD 3, SIMD 4, and SIMD 5 (the 20% least deprived areas), for children that were targeted for a fluoride varnish application, there was no pattern of change observed in the odds of Caries Experience regardless of the number of fluoride varnish applications a child received.

Overall there was a slight attenuation on the effect of receiving fluoride varnish applications in nursery and school (although this was strongest in SIMD 1 and SIMD 2) but it remained independently associated with Caries Experience (Tables 4-16 to 4-17 and Figure 4-11).

Table 4-16: Logistic Regression of 'Nursery and School Fluoride Varnish Applications' in Relation to Caries Experience: Model One* and Model Two Adjustments**

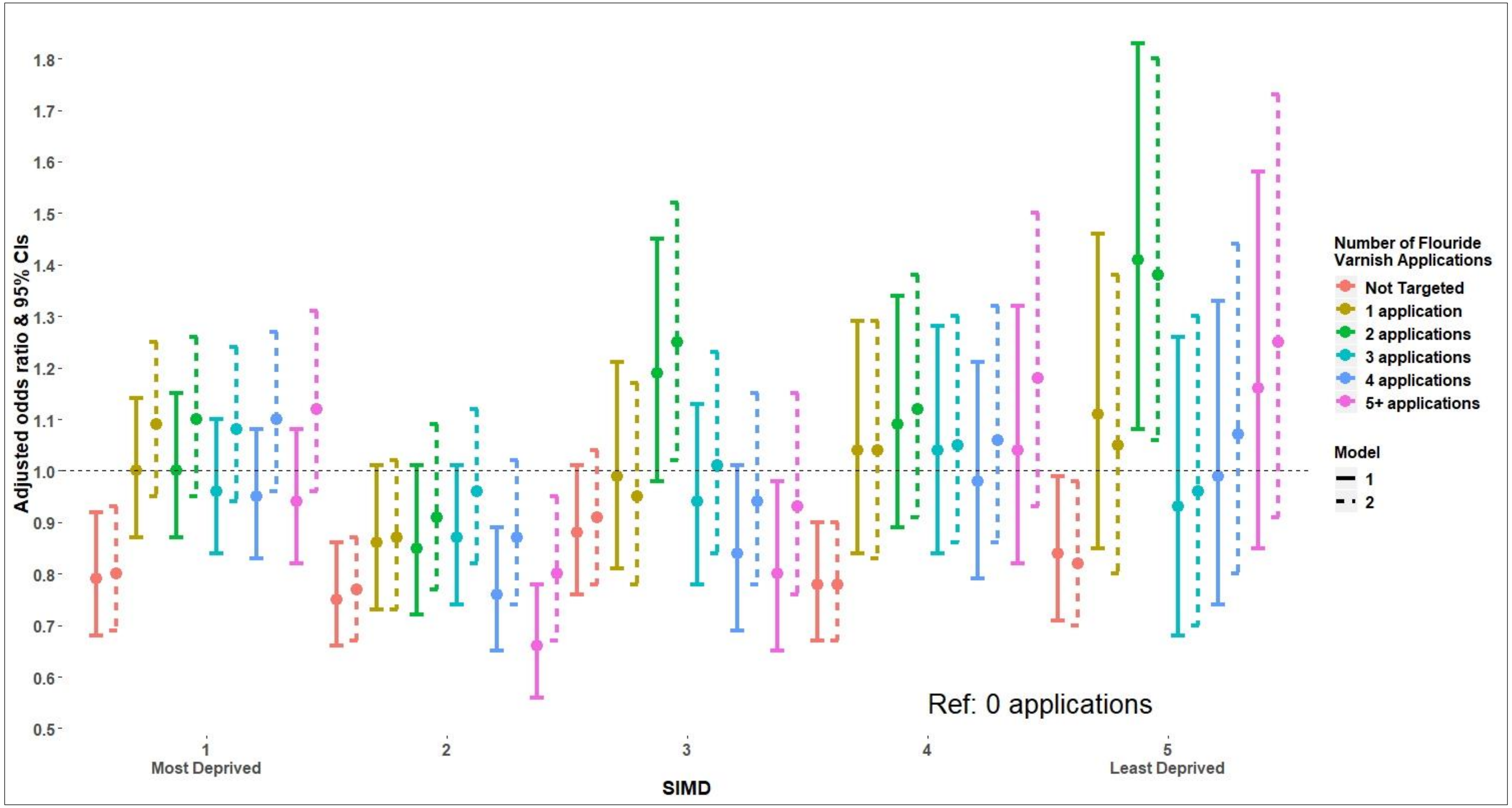
Number of Applications	Caries Experience n	%	No Caries Experience n	%	Total	Model One AOR	Model One 95% CI		Model One p-value	Model Two AOR	Model Two 95% CI		Model Two p-value
Not Targeted	4,306	(23%)	14,492	(77%)	18,798	0.80	(0.75,	0.85)	<0.001	0.81	(0.75,	0.86)	<0.001
0 applications	2,233	(32%)	4,735	(68%)	6,968	-	Referent		-	-	Referent		-
1 application	1,676	(35%)	3,094	(65%)	4,770	0.98	(0.90,	1.06)	0.575	0.98	(0.90,	1.07)	0.643
2 applications	1,676	(36%)	3,006	(64%)	4,682	1.03	(0.95,	1.12)	0.468	1.07	(0.99,	1.16)	0.101
3 applications	1,844	(35%)	3,479	(65%)	5,323	0.95	(0.87,	1.02)	0.156	1.01	(0.93,	1.09)	0.855
4 applications	1,843	(34%)	3,640	(66%)	5,483	0.89	(0.82,	0.96)	0.003	0.99	(0.91,	1.07)	0.789
5 plus applications	1,454	(33%)	2,901	(67%)	4,355	0.86	(0.79,	0.93)	<0.001	0.99	(0.91,	1.08)	0.779
Total	15,032	(30%)	35,347	(70%)	50,379								

Model Two Logistic Regression Results for 'Nursery and School Fluoride Varnish Applications'

Type 3 Results:	Chi-Square	Df	p-value	C-index
	85.87	6	<0.001	0.66

*Model One is the logistic regression adjusted by the Scottish Index of Multiple Deprivation Index (SIMD), sex, and age; **Model Two is the logistic regression adjusted by SIMD, sex, age, the three other Childsmile Components (Dental Health Support Worker Contacts, Childsmile Dental Practice Contacts and Time Toothbrushing).

Figure 4-11: Model One* and Model Two Odds Ratios and 95% Confidence Intervals of 'Nursery and School Fluoride Varnish Applications' in Relation to Caries Experience by SIMD**



***Model One is the logistic regression adjusted by the Scottish Index of Multiple Deprivation Index (SIMD), sex, and age; **Model Two is the logistic regression adjusted by sex, age, the three other Childsmile Components (Dental Health Support Worker Contacts, Childsmile Dental Practice Contacts and Time Toothbrushing).

Table 4-17: Logistic Regression of 'Nursery and School Fluoride Varnish Applications' in Relation to Caries Experience by SIMD: Model One* and Model Two Adjustments**

SIMD	Time	Caries Experience N	%	No Caries Experience n	%	Total	Model One AOR	95% CI		p-value	Model Two AOR	95% CI		p-value
1	**Not Targeted**	503	(41%)	739	(60%)	1242	0.79	(0.68,	0.92)	0.002	0.80	(0.69,	0.93)	0.004
	0 applications	771	(46%)	905	(54%)	1676	-	Referent		-	-	Referent		-
	1 application	821	(46%)	963	(54%)	1784	1.00	(0.87,	1.14)	0.979	1.09	(0.95,	1.25)	0.238
	2 applications	780	(46%)	914	(54%)	1694	1.00	(0.87,	1.15)	0.998	1.10	(0.95,	1.26)	0.205
	3 applications	865	(45%)	1054	(55%)	1919	0.96	(0.84,	1.10)	0.542	1.08	(0.94,	1.24)	0.281
	4 applications	881	(45%)	1069	(55%)	1950	0.95	(0.83,	1.08)	0.429	1.10	(0.96,	1.27)	0.174
	5 plus applications	689	(46%)	823	(54%)	1512	0.94	(0.82,	1.08)	0.396	1.12	(0.96,	1.31)	0.146
	Total	5310	(45%)	6467	(55%)	11777								
2	**Not Targeted**	939	(34%)	1867	(67%)	2806	0.75	(0.66,	0.86)	<0.001	0.76	(0.67,	0.87)	<0.001
	0 applications	571	(40%)	856	(60%)	1427	-	Referent		-	-	Referent		-
	1 application	386	(36%)	676	(64%)	1062	0.86	(0.73,	1.01)	0.065	0.87	(0.73,	1.03)	0.100
	2 applications	343	(36%)	603	(64%)	946	0.85	(0.72,	1.01)	0.060	0.91	(0.77,	1.09)	0.306
	3 applications	473	(37%)	819	(63%)	1292	0.87	(0.74,	1.01)	0.075	0.96	(0.82,	1.12)	0.601
	4 applications	472	(34%)	923	(66%)	1395	0.76	(0.65,	0.89)	<0.001	0.87	(0.74,	1.02)	0.091
	5 plus applications	365	(31%)	799	(69%)	1164	0.66	(0.56,	0.78)	<0.001	0.80	(0.67,	0.95)	0.010
	Total	3549	(35%)	6543	(65%)	10092								

3	**Not Targeted**	1065	(26%)	3017	(74%)		0.88	(0.76,	1.01)	0.065	0.91	(0.78,	1.04)	0.168
	0 applications	373	(29%)	929	(71%)	1302	-	Referent		-	-	Referent		-
	1 application	213	(28%)	540	(72%)	753	0.99	(0.81,	1.21)	0.956	0.95	(0.78,	1.17)	0.625
	2 applications	242	(32%)	511	(68%)	753	1.19	(0.98,	1.45)	0.080	1.25	(1.02,	1.52)	0.028
	3 applications	255	(27%)	685	(73%)	940	0.94	(0.78,	1.13)	0.497	1.01	(0.84,	1.23)	0.901
	4 applications	245	(25%)	723	(75%)	968	0.84	(0.69,	1.01)	0.062	0.94	(0.78,	1.15)	0.561
	5 plus applications	204	(25%)	607	(75%)	811	0.80	(0.65,	0.98)	0.029	0.93	(0.76,	1.15)	0.518
	Total	2597	(27%)	7012	(37%)	9609								
4	**Not Targeted**	979	(20%)	4041	(81%)	5020	0.78	(0.67,	0.90)	<0.001	0.78	(0.67,	0.90)	<0.001
	0 applications	302	(24%)	976	(76%)	1278	-	Referent		-	-	Referent		-
	1 application	168	(24%)	523	(76%)	691	1.04	(0.84,	1.29)	0.737	1.04	(0.83,	1.29)	0.758
	2 applications	207	(25%)	610	(75%)	817	1.09	(0.89,	1.34)	0.397	1.12	(0.91,	1.38)	0.269
	3 applications	189	(24%)	587	(76%)	776	1.04	(0.84,	1.28)	0.722	1.05	(0.85,	1.30)	0.635
	4 applications	176	(23%)	579	(77%)	755	0.98	(0.79,	1.21)	0.838	1.06	(0.86,	1.32)	0.590
	5 plus applications	133	(25%)	406	(75%)	539	1.04	(0.82,	1.32)	0.740	1.18	(0.93,	1.50)	0.185
	Total	2154	(22%)	7722	(78%)	9876								

5	**Not Targeted**	820	(15%)	4828	(86%)	5648	0.84	(0.71,	0.99)	0.036	0.82	(0.70,	0.98)	0.025
	0 applications	216	(17%)	1069	(83%)	1285	-	Referent		-	-	Referent		-
	1 application	88	(18%)	392	(82%)	480	1.11	(0.85,	1.46)	0.445	1.05	(0.80,	1.38)	0.736
	2 applications	104	(22%)	368	(78%)	472	1.41	(1.08,	1.83)	0.011	1.38	(1.06,	1.80)	0.016
	3 applications	62	(16%)	334	(84%)	396	0.93	(0.68,	1.26)	0.620	0.96	(0.70,	1.30)	0.771
	4 applications	69	(17%)	346	(83%)	415	0.99	(0.74,	1.33)	0.950	1.07	(0.79,	1.44)	0.673
	5 plus applications	63	(19%)	266	(81%)	329	1.16	(0.85,	1.58)	0.356	1.25	(0.91,	1.73)	0.170
	Total	1422	(16%)	7603	(84%)	9025								

*Model One is the logistic regression adjusted by the Scottish Index of Multiple Deprivation Index (SIMD), sex and age; **Model Two is the logistic regression adjusted by sex, age, the three other Childsmile Components (Dental Health Support Worker Contacts, Childsmile Dental Practice Contacts and Time Toothbrushing).

4.4.6 Investigating the independent effect of the Childsmile Components in relation to Caries Experience (Model Three)

The results of the forward stepwise model indicate that of all the Childsmile components, ‘Childsmile Dental Practice Contacts’, which was entered first into the model, was explaining the greatest amount of variation in Caries Experience. Had a component not been entered into the model, this would have indicated that it did not have an independent effect on Caries Experience. As all four components were entered into the model and none were excluded, each Childsmile component must also have an independent effect on Caries Experience reduction, although the significance of each component reduced as it entered the model having been adjusted for the components that had entered the model previously. Note that the p-values in Table 4-18 are very small (highly significant) due to the large cohort size in this study.

Table 4-18: Forward Model Fitting for Childsmile Components

Step	Variable	Df	χ^2	p-value
1	Childsmile Dental Practice Contacts	10	379.25	<0.001
2	Dental Health Support Worker Contacts	3	77.42	<0.001
3	Nursery and School Fluoride Varnish Applications	6	66.17	<0.001
4	Time Consented to Toothbrushing	3	74.68	<0.001

SIMD – Scottish Index of Multiple Deprivation

As all four components were entered into the stepwise model, the c-indexes of the four Model One adjusted components were examined to determine if there was a difference observed in each of their predictabilities (Tables 4-5 to 4-8). The c-index was just 0.01 higher for Childsmile Dental Practice contacts in comparison to the other three components (0.65). It therefore had a slightly greater predictive ability, but essentially the four components were similar with regards to their association with reduction in Caries Experience.

4.4.6.1 Considering the Relative Importance of each the Childsmile Components in relation to Caries Experience

The categories (frequency levels) within each of the Childsmile components are not directly comparable given different meaning of data, number of strata with each other - for example, nursery and school toothbrushing consent covers participation in this component for the year (with a maximum number of two to three years). Whereas the number of contacts in the practice can cover a five-year period and reach much higher frequencies (n > 10). Thus, a quantitative analysis comparison would be limited. This section is a descriptive comparison of the relative impact of each of the components, firstly at an overall population level, then for children living in the 40% most deprived areas.

Relative Importance of each the Childsmile Components in relation to Caries Experience at a Population Level

Two years or greater of supervised toothbrushing resulted in decreased odds of Caries Experience of 19% in comparison to those that were not part of the toothbrushing programme (Table 4-7). This degree of reduction is very similar to the 18% reduction in Caries Experience associated with having three Childsmile appointments (contacts) at a dental practice (Table 4-6). This comparison does not consider the timing of the Childsmile Dental Practice Contacts (or what happened during the appointment). The dental practice contact allows for two appointments per year. Six contacts (spread over three years) confers reduced odds of Caries Experience by 42% - which is a considerably higher reduction in risk when compared to the 19% risk reduction for children with the intended three years of supervised toothbrushing in nursery.

Children targeted and receiving five or more fluoride varnishes in the nursery and school fluoride varnish component have a 14% reduced odds of Caries Experience (Table 4-8), whereas just having three Childsmile Dental Practice contacts has reduced odds of 18% (Table 4-6). Children should only have received a fluoride varnish application twice per year in the nursery and school setting (as per programme guidelines), so it can be assumed that five plus varnishes would be the equivalent time of two years or more of supervised toothbrushing – with toothbrushing over the time-period providing a 19% reduction in risk of Caries Experience.

One contact with a DHSW resulted in a reduced odds experience of 37% in comparison to those targeted and not being contacted. The odds of caries then increase again with two or more contacts, so unlike the other three components, there was not a dose response observed (Table 4-5).

Relative Importance of each the Childsmile Components for Children in the 40% Most Deprived Areas

As there was no interaction between Childsmile Dental Practice Contacts and socioeconomic deprivation (SIMD), it can be assumed the odds of caries for each number of contacts would be approximately the same across each of the SIMD quintiles (Table 4-9). For children in SIMD 1, more than two years of participation in the supervised toothbrushing programme had a 30% reduction in odds of Caries Experience (Table 4-10), the equivalent of four Childsmile Dental Practice Contacts (reduced odds of 29%). For children in SIMD 2, more than two years of toothbrushing had a 36% reduction in odds of Caries Experience, the equivalent of five Childsmile Dental Practice Contacts (reduced odds also of 36%).

Children within SIMD 1 receiving five or more fluoride varnish applications only had an insignificant reduction in odds of Caries Experience for targeted children (AOR = 0.94; 95% CI = [0.82 to 1.08]), making it difficult for a relative comparison to be made with the other components (Table 4-11). In SIMD 2, however, five plus fluoride varnish applications resulted in reduced odds of 34%, similar to the 36% observed in SIMD 2 for two plus years of supervised toothbrushing and for five Childsmile Dental Practice Contacts (Table 4-6).

4.5 Investigation of Childsmile Dental Practice Contacts

As indicated in Section 4.4.5.2, the effect of the ‘Childsmile Dental Practice Contacts’ component was independent of the three other types of Childsmile components with the odds of Caries Experience decreasing as the number of contacts increased. These dental practice visits can involve a number of components, including, diet advice and toothbrushing advice (defined together as ‘Oral Health Advice’) and fluoride varnish application. A further set of analyses were conducted for this variable to explore whether Childsmile Dental Practice Contacts with or without the clinical preventive component (fluoride varnish application) had the greatest impact on Caries Experience.

Table 4-19 shows that within the cohort: 14,842 (29%) never attended a dental practice for a Childsmile contact; 10,052 (20%) attended at least twice and received a fluoride varnish application on at least one contact and also did not receive a fluoride varnish application on at least one other occasion; 8,397 (17%) attended a dental practice at least once and never received a fluoride varnish; while 14,088 (28%) attended at least once and received a fluoride varnish application on every visit to the dental practice.

Table 4-19: Children Receiving Fluoride Varnish Applications at a Childsmile Dental Practice Contact

Never Attended	14,842	(29%)
Attended at least twice and received an FVA on at least one occasion <u>and</u> did not receive an FVA on at least one other occasion	10,052	(20%)
Attended at Least Once and <u>Never</u> Received an FVA	8,397	(17%)
Attended at Least Once and <u>Always</u> Received an FVA	14,088	(28%)
Total Children in the Cohort	50,379	

FVA: Fluoride Varnish Application

Subset One (n = 23,239) included all of the children that had attended a Childsmile appointment at a dental practice but had never received a fluoride varnish application plus all of the children that had never attended a Childsmile appointment at a dentist who were the referent category (Table 4-20). The second subset (n = 28,930) included all of the children that had attended a Childsmile dental practice appointment and had received an FVA at every visit plus all children that had never attended a dentist who were again the referent category (Table 4-21).

In both subsets, the variable ‘Childsmile Dental Practice Contacts’ has seven categories: ‘0 Childsmile contacts’, ‘1 contact’, ‘2 contacts’, ‘3 contacts’, ‘4 contacts’, ‘5 contacts’ and ‘6 plus contacts’. Children that never had a Childsmile contact at a dental practice was the referent category selected.

The absolute risk of Caries Experience was similar in each of the subsets; 30% for those never receiving a fluoride varnish application and 31% for those receiving it at every visit.

Children with no fluoride varnish applications had a reduction in the odds of Caries Experience as the number of Childsmile dental practice contacts increased from two to six plus (AOR = 0.78 to 0.39) compared to those that have never had a Childsmile contact in a dental practice.

For those children always receiving fluoride varnish applications, there was an increase in the odds of Caries Experience for children having up to two contacts (AOR = 1.11; 95% CI = (1.03 to 1.21) when compared to children that had never attended a dental practice. From three contacts on, however, there was a substantial decrease in the odds of Caries Experience as the number of contacts increased to six plus (AOR = 0.36; 95% CI = (0.25 to 0.52).

The effect of the total number of contacts in reducing the odds of Caries Experience remained more pronounced in the non-fluoride varnish subset for three and four contacts (although there was an overlap in the 95% confidence intervals for children with four contacts across both subsets). The effect of the number of contacts had balanced across both subsets by 6 plus contacts, however, (AOR = 0.39; 95% CI = [0.25 to 0.70] for children never having received a fluoride varnish and AOR = 0.36; 95% CI = [0.25 to 0.52] for children always having received a fluoride varnish.

None of the p-values in the interaction test between the two subsets and the potential confounders (sex, age and SIMD) were statistically significant (Table 4-22). Therefore, there were no interactions between the two types of Childsmile contacts at a dental practice with the potential confounders on their effect on Caries Experience.

Overall, although children that had up to three contacts but had never received a fluoride varnish had lower odds of Caries Experience in comparison to those that had always received a fluoride varnish, there was no further difference observed between the two types of contacts as the number of contacts increase beyond this.

Table 4-20: Logistic Regression of 'Childsmile Dental Practice Contacts – No Fluoride Varnish' in Relation to Caries Experience: Unadjusted and Model One* Adjustment

Number of Contacts	Caries Experience n	%	No Caries Experience n	%	Total	Unadjusted OR	95% CI		p-value	Model One AOR	95% CI		p-value
0 Childsmile contacts	4798	(32%)	10134	(68%)	14842	-	Referent		-	-	Referent		-
1 contact	1528	(33%)	3131	(67%)	4659	1.05	(0.98,	1.13)	0.170	0.97	(0.90,	1.04)	0.421
2 contacts	560	(28%)	1438	(72%)	1998	0.84	(0.76,	0.93)	<0.001	0.78	(0.70,	0.87)	<0.001
3 contacts	218	(23%)	746	(77%)	964	0.63	(0.54,	0.73)	<0.001	0.59	(0.51,	0.69)	<0.001
4 contacts	92	(21%)	348	(79%)	440	0.57	(0.45,	0.72)	<0.001	0.55	(0.43,	0.69)	<0.001
5 contacts	35	(19%)	152	(81%)	187	0.50	(0.34,	0.72)	<0.001	0.48	(0.33,	0.70)	<0.001
6 plus contacts	25	(17%)	124	(83%)	149	0.43	(0.28,	0.67)	<0.001	0.39	(0.25,	0.70)	<0.001
Total	7256	(30%)	16073	(70%)	23239								

Model One Logistic Regression Results of 'Childsmile Dental Practice Contacts – No Fluoride Varnish'

Type 3 Results:	Chi-Square	Df	p-value	C-index
	109.25	6	<0.001	0.65

*Model One is the results of the logistic regression adjusted by the Scottish Index of Multiple Deprivation Index (SIMD), sex, and age.

Table 4-21: Logistic Regression of 'Childsmile Dental Practice Contacts – Fluoride Varnish' in Relation to Caries Experience: Unadjusted and Model One* Adjustment

Number of Contacts	Caries Experience n	%	No Caries Experience n	%	Total	Unadjusted OR	95% CI		p-value	Model One AOR	95% CI		p-value
0 Childsmile contacts	4708	(32%)	10134	(68%)	14842	-	Referent		-		Referent		-
1 contact	2171	(36%)	3823	(64%)	5994	1.22	(1.15,	1.30)	<0.001	1.25	(1.17,	1.33)	<0.001
2 contacts	1181	(33%)	2425	(67%)	3606	1.05	(0.97,	1.13)	0.234	1.11	(1.03,	1.21)	0.008
3 contacts	542	(25%)	1617	(75%)	2159	0.72	(0.65,	0.80)	<0.001	0.80	(0.72,	0.89)	<0.001
4 contacts	280	(21%)	1033	(79%)	1313	0.58	(0.51,	0.67)	<0.001	0.67	(0.58,	0.77)	<0.001
5 contacts	127	(17%)	622	(83%)	749	0.44	(0.36,	0.53)	<0.001	0.52	(0.42,	0.63)	<0.001
6 plus contacts	33	(12%)	234	(88%)	267	0.30	(0.21,	0.44)	<0.001	0.36	(0.25,	0.52)	<0.001
Total	9042	(31%)	19888	(69%)	28930								

Model One Logistic Regression Results of 'Childsmile Dental Practice Contacts - Fluoride Varnish'

Type 3 Results:	Chi-Square	Df	p-value	C-index
	198.72	6	<0.001	0.66

*Model One is the results of the logistic regression adjusted by the Scottish Index of Multiple Deprivation Index (SIMD), sex, and age.

Table 4-22: Interaction Test of SIMD, Sex and Age with 'Childsmile Dental Practice Contacts – No Fluoride Varnish' and 'Childsmile Dental Practice Contacts – Fluoride Varnish'

Component	SIMD P-Type 3	Sex P-Type 3	Age P-Type 3
Childsmile Dental Practice Contacts – No Fluoride Varnish'	0.530	0.242	0.919
Childsmile Dental Practice Contacts – No Fluoride Varnish'	0.734	0.614	0.603

SIMD: Scottish Index of Multiple Deprivation.

4.6 Chapter 4 Summary

The delivery of Childsmile varies across each component. The targeted components of Childsmile, 'DHSW Contacts' and 'Nursery and School Fluoride Varnish Applications' were more likely to be participated in by children living in higher areas of deprivation. There was only a small variation in the rate of children participating in the Childsmile dental practice component in terms of deprivation status. The rate of consent to toothbrushing was higher for children living in areas of high deprivation and there was no difference observed in the rate of children who had been consented to toothbrushing for the maximum amount of time.

In this cohort of children receiving a Primary One NDIP inspection in 2014/2015, all four Childsmile components were found to have a positive impact on Caries Experience both individually (after adjustment for potential confounders) as well as being independent of each other with only minor changes of effect observed following mutual adjustment throughout. Where appropriate, dose response relationships were observed whereby increased component density was associated with less Caries Experience. For two of the components ('Time Toothbrushing' and 'Nursery and School Fluoride Varnish Applications'), interactions with SIMD indicated a stronger effect of the Childsmile programme within more deprived groups – although the relationship was less pronounced for nursery and school fluoride varnish with no significant caries preventive effect observed in children from the most deprived (SIMD 1) communities.

Chapter 5 – Discussion, Conclusions, and Recommendations

5.1 Key Findings

This thesis has several important findings:

i) It was possible to create a study cohort via data linkage of routine administrative datasets and to undertake an initial evaluation of the impact of the components of the Childsmile Programme - a complex multifaceted national public health intervention - on the oral health of five-year-old-children.

ii) The four main components of the Childsmile programme examined are largely being delivered as envisaged with respect to their differing targeted and universal aims, however, there remains room to improve the reach of aspects of the programme.

iii) For the full cohort, there were significantly reduced odds of caries experience among five-year-olds for three of the four components: two years plus of supervised toothbrushing consent AOR = 0.75; 10 plus Childsmile dental practice contacts AOR = 0.33; and one contact with a DHSW AOR = 0.69 (although this attenuated for two or more DHSW contacts to AOR = 0.94). There were no significant reduced odds of caries for the nursery and school fluoride varnish component where five plus fluoride varnish applications AOR = 0.99.

iv) For two of the components, the association with reduced dental caries was modified by the area-based socioeconomic deprivation (SIMD) of the child's home. Supervised toothbrushing appeared to be associated with a lower odds of caries experience in children from the most deprived areas (SIMD categories 1 and 2). For nursery and school fluoride varnish, there was lower odds as the number of applications increased, although this was not significant for children in the SIMD 1 category, and was only significant for those from the SIMD 2 category after receiving four or five applications.

v) There was no additional benefit of fluoride varnish application, over and above regular attendance at a dental practice, in terms of lowering the odds of caries development in five-year-olds.

5.2 The creation of a study cohort via data linkage

5.2.1 Summary of the creation of a study cohort via data linkage

Accessing robust and high-quality data in the National Safe Haven is a complex and laborious procedure. This study, however, successfully navigated the multiple and comprehensive approval processes. It also piloted and tested the National Safe Haven environment and validated the data linkage process through developing and undertaking thorough and robust data quality and completeness check procedures.

The linked datasets within the National Safe Haven and the computer programming that was designed to further link and analyse the data were able to provide insight into the delivery of each component of Childsmile and their association with Caries Experience. It has also paved the way for further evaluation and research related to Childsmile and child oral health (see Section 5.8.1 for details).

5.2.2 Discussion of the Data Linkage and National Safe Haven

It was a very long and winding journey from i) identifying the datasets that could answer the research questions to evaluate the potential effectiveness of the multiple components of Childsmile, to ii) accessing the data within the National Safe Haven with computer code, and iii) building and analysing the individual-level cohort.

The methods of previous data linkage studies provided an excellent starting point for performing data quality checks and improving the quality of the data once the data were uploaded into the National Safe Haven (Clark, 2015; Clark et al., 2017). Having such a large number of datasets, however, which needed to be indexed and uploaded into the National Safe Haven, had not previously been managed and this was a challenge for all involved. Much of the methods to access and manage large datasets within the National Safe Haven were piloted, and quality and completeness check procedures were developed through the pilot work and methods of this thesis.

The initial data linkage process that was undertaken by eDRIS involved the removal of an identifiable linkage ID (CHI), which was then replaced with a pseudo-anonymised ID. In theory, this should have allowed the matching of corresponding records for individual children to be undertaken in the Safe Haven by the author of this thesis. When working with a specialist data linkage team like eDRIS, it was perhaps naive to assume that the aforementioned process would have occurred with limited error. As the entire analysis process relied on correctly matching linked datasets within the Safe Haven, any errors that occurred during the linkage process would (and did) have serious consequences for the study. The work of this thesis involved negotiation with the NHS National Services Scotland Caldicott Guardian to include the full date of birth for each record in the study. Initially the Caldicott Guardian would only provide month and year of birth. The case was made for the requirement within this detailed epidemiological analysis for the full date of birth to enable accurate age to be calculated when measuring outcomes for young children. This was considered important because dental caries progression is strongly related to age in young children (McMahon et al., 2011; Blair et al., 2015).

The inclusion of full date of birth also provided additional benefits. Firstly, it enabled validation by identifying inaccurate linkages; and secondly it improved data quality by enabling accurate decisions relating to the data such as identifying clear cut-off thresholds for the indexing probability match weight score.

The initial difficulties experienced in this study with regards to data quality highlighted the importance of performing initial data quality checks immediately after the data becomes available to avoid costly and lengthy delays. This thesis developed a tranche of relatively quick and simple data quality and completeness checks including – comparing dates of birth matches across datasets, looking at sex distribution in included datasets, and assessing the completeness (numbers/proportions) of datasets against what is expected from the data source description or existing published reports which have used these datasets (albeit without linkage).

5.3 Explanations and Interpretations

5.3.1 Explanations and Interpretations of the Dental Health Support Worker Component

Reach of DHSW Component

The DHSW component was intended to be targeted to those with greatest need – likely to be children from the poorest socioeconomic areas, but there was the individual clinical discretion of the Health Visitor making the referral. Overall, rates of contact with the DHSW component were relatively low - with only 17% of the child population cohort having contact with a DHSW. Over two thirds of children from the most deprived SIMD had not received a DHSW contact. There was, however, a socioeconomic gradient in contact observed (from 30% of children from the most deprived areas to 8% in the least deprived) which demonstrates a degree of socioeconomic targeting. Of SIMD 1 children that were targeted for a contact, the majority (89%) received at least one contact, whilst for all SIMD groups, it was 90%.

Since the 2014/2015 Childsmile headline report, there does not seem to have been any substantial changes in the delivery of this component up to and including the most recent 2017/2018 monitoring report (which also includes data from previous years) (Central Evaluation & Research Team, 2018). The data in the reports are not directly comparable due to reporting all DHSW contacts in the reporting period regardless of the year of birth. However, out of the 14,264 children contacted at least once by a DHSW in 2017/2018, 39% were for SIMD 1 children. This is the same proportion as seen in the study cohort, where of the 8,753 children with at least one contact, 40% were also SIMD 1 children.

Initially, within each health board, the DHSW role was only funded to a level that supports them contacting around 20% to 30% of the children in their board. However, it should be noted that health boards vary in the allocation of activities of Childsmile with some having joint roles that also include assisting with the nursery and school fluoride varnish component. The DHSW component, (defined in the thesis as the family contact role), if operating as envisaged, should enable them to contact more children living in the most deprived areas of their health board. The referral to a DHSW, however, is a decision for the family

Health Visitor who will be referring children who they deem are in need – given the social gradient in health these may be across the area-based socioeconomic deprivation groups. There was anecdotal evidence to suggest that in some geographical areas, all children in that district or community were being universally referred to a DHSW by Health Visitors (Hodgins, 2017). This could have led to the DHSW contacting families that did not require DHSW support and who should have instead been signposted directly to a dental practice by the Health Visitor (without the additional support of a DHSW).

Additionally, the distribution of deprivation across Scotland is not equally shared – with greater concentrations of deprivation in the West of Scotland. In NHS Greater Glasgow & Clyde for example, 37% of the health board population lives in the 20% most deprived areas nationally, whereas in NHS Grampian, only 4% of the health board population lives in the 20% most deprived areas nationally (Scottish Government, 2016c). The children most in need of support of a DHSW are those from the most deprived areas and the national level index would be the most accurate way to define this.

These findings support the need to ensure the DHSW resources are better focused on children / families from the more deprived communities, acknowledging that some families living in affluent areas may at the individual level be in need of this support (an example of the concerns associated with applying area-based indicators to individuals).

DHSW Contact Association with Caries Experience

Children that were targeted for DHSW Contacts had reduced odds of caries that were comparable to those children who were not targeted, if the family only met with a DHSW on a single occasion. However, a reduction in the odds of Caries Experience was not observed as the number of contacts increased, in fact the odds of caries experience increased. These trends were observed across the full cohort regardless of deprivation status due to their being no significant interaction with deprivation.

As mentioned above, some families not necessarily in need of a DHSW visit could have received one contact; however, the lack of interaction with deprivation would appear to show that the effect of one DHSW contact on reducing odds of dental caries was the same across all deprivation groups. Thus, the initial DHSW contact with provision of a caries risk assessment and tailored support was sufficient to lead to a reduced odds of caries among some children.

The explanation for why families with more than one DHSW contact did not seem to have the same caries reduction benefit as those receiving one contact could relate to the potential greater needs of these families. Accordingly, DHSWs were able to identify those families who required further and additional support (through subsequent / repeated DHSW visits). Conversely, this additional support did not seem to be sufficient to mitigate against the increased risk of caries among these vulnerable children and families. The DHSW data used in the thesis were limited in that they could only give us accurate information about the contact, but not about the nature of the tailoring of support or the intensity of the dietary, toothbrushing, and other advice given during the appointment.

The work of Hodgins et al. (2018) showed that DSHWs were successful in supporting children from the most deprived areas in attending a dental practice much earlier than those children of similar deprivation status who were not contacted. However, again, the effectiveness of the behavioural (largely health educational) one-to-one advice given to parents/carers was uncertain. Their work implies that the DHSW has had some role in changing the oral health attitudes of those families that they had contacted, as attending a dental practice involves families adopting an active approach over and above the more passive approach of the DHSW visiting them in the family home. As these families were now potentially more motivated to attend a dental practice than their peers, it can therefore be hypothesised that the DHSW may also have motivated these families to a level that they also adopted more positive oral health behaviours at home. This could go some way to explaining the reduction in the odds of dental caries of those targeted children who were contacted just once, to the level of those children that had previously been deemed by a health visitor as not requiring additional oral health support (i.e. not targeted).

An earlier qualitative study of the effectiveness of the role of DHSWs found that DHSWs only had the resources to support those families who were identified at being of low to medium risk of caries, rather than those at high risk (Young, 2017). Therefore, DHSWs are perhaps unable to provide the required level of support to those who are at higher risk, which could explain why those children receiving two or more contacts did not have the same (or even better) reduction in the risk of caries experience as those who had only one DHSW contact. This also further supports the case for a redistribution and refocusing of funding so that the DHSWs have more time available to support the higher risk families.

5.3.2 Explanations and Interpretations of the Dental Childsmile Dental Practice Component

Reach of Childsmile Dental Practice Component

The Childsmile Dental Practice was intended as a universal component. Children from the least socioeconomically deprived areas were only slightly more likely to receive a Childsmile Dental Practice Contact, with the difference across the SIMD quintiles being minimal. The proportions of contacts that were observed across the SIMD quintiles in the analysis cohort varied from 69% in children from SIMD 1 to 72% in those from SIMD 5. These findings, with over two-thirds of the cohort attending a Childsmile dental practice, reflect the increased rates and reduction in socioeconomic inequalities of registration and attendance of children with NHS dental practices in Scotland (ISD Scotland, 2018a). A previous analysis (utilising the Childsmile linked data infrastructure created by the work of this thesis) identified that DHSWs were effective at getting targeted children from more deprived areas into a dental practice earlier than expected (Hodgins et al., 2018). This may in part explain the large reduction in socioeconomic inequalities in the registration and attendance of children at dental practices in Scotland.

Childsmile monitoring reports have shown that the attendance of children at Childsmile dental practices has increased since the thesis end-point of 2015. The proportion of children registered with an NHS dentist that attended at least once for a Childsmile appointment within the 2014/2015 financial year was 68% for children aged two years and under and 40% for three to five-years-olds, and come the 2017/2018 financial year, it was 78% and 48%, respectively (Central Evaluation & Research Team, 2015). In terms of socioeconomic deprivation level of the children, there remains very small differences in the delivery across the SIMD quintiles. It is worth noting from the Childsmile monitoring reports (Central Evaluation & Research Team, 2015) that there are very slightly higher rates of children from SIMD 1 aged two years and under attending, whereas the opposite is observed for the older age group, which is in keeping with a previous

Childsmile analysis as discussed above (Hodgins et al., 2018). These monitoring data show some success in achieving an initial Childsmile dental practice contact in children from the most deprived communities in the early years, but the data also indicate that there is perhaps an ongoing challenge in maintaining this attendance as the child gets older. This thesis found a similar inverse relationship with children by five years old from the most affluent areas having been slightly more likely to have had at least one Childsmile dental practice contact by the time of their dental inspection.

Childsmile Dental Practice Contact Association with Caries Experience

There was a strong gradient or dose response in relation to attendance at Childsmile Dental Practice as the number of contacts increased from three upwards. These trends were observed across the full cohort regardless of deprivation status due to their being no significant interaction with deprivation.

These thesis results are similar to previous findings first noted in a much earlier study in the North East of England where five-year-old children that attended the dentist irregularly have increased rates of mean dmft in comparison to regular attenders, and that socioeconomic status did not impact on the level of restorative treatment required (Tickle et al., 1999). The cross-sectional observation of poor oral health and self-reported (irregular) dental attendance is well reported – and documented in the more recent UK Child Dental Health Surveys (Tsakos et al., 2015).

In the present cohort, there was an overall trend of a reduction of risk as the number of Childsmile dental practice contacts increased. Children who had attended only once had a small (albeit significant) increased odds of caries compared to those children that had never attended. A plausible explanation for this seemingly paradoxical result, is that these ‘one-off’ dental attenders may have included some higher risk children who the DHSWs had managed to support into attending a practice appointment (Hodgins et al., 2018). However, an issue may be the challenge of ongoing retention of these children in the programme. This interpretation is supported by this thesis author’s previous research into the retention of children in Childsmile dental practices (Kidd, 2012), which showed that 56% of the children living in the 20% highest areas of deprivation (i.e. those children traditionally at higher risk) who had attended once did not return for a second appointment in the subsequent twelve months in comparison to 50% of those children from the 40% least deprived areas. This may in part be due to a lack of a tailored approach at this first visit (Yuan et al., In press), with families perhaps not perceiving any value in attendance.

Moreover, the national published data on children's dental service engagement in Scotland (ISD Scotland, 2018a) shows that there were high levels of, and no inequalities in, dental registration rates, but there were wider inequalities and lower levels of 'participation' (a measure of regular attendance i.e. attended at least once in a two year period). The policy in Scotland changed to lifetime registration in 2010- since then registration rates have markedly risen (NHS Education for Scotland, 2014). Lifetime dental registration means that patients only require a single attendance at a dental practice to maintain registered, therefore, registration is no longer a good marker of attendance per se, and hence the participation attendance measure was created (ISD Scotland, 2018a).

As there was no significant interaction between Childsmile Dental Practice contacts and SIMD observed in the cohort analysis, consistent reduced odds associated with caries experience with increasing dental practice contacts would have been experienced across all SIMD groups. After reporting similar results, Tickle et al., (1999) concluded that families who attend the dentist regularly, regardless of socioeconomic status, may already also have other good oral health habits such as regular toothbrushing at home. This was further supported by more recent data from North West England that estimated that 83% of children have no obvious caries when they first present to a dental practice (Milsom et al., 2008). It is difficult not to draw a similar conclusion from the results of this thesis analysis, i.e. that regular Childsmile Dental Practice Contacts was a marker for better oral health as the result of motivated, enabled, and health conscious parents/carers, rather than being genuinely causal in reducing caries risk. However, the alternative explanation that regular Childsmile Dental Practice attendance could also have a role to play in ensuring that children have no dental caries (through their delivery of preventive interventions) cannot be ruled out. Furthermore, the limited evidence of effectiveness of chairside advice-based health education interventions casts some doubt on the role of dental teams in driving oral health improvement, e.g. there remains limited trial or systematic review evidence on the preventive effect of diet or toothbrushing advice (Harris et al., 2012), and even the effectiveness of practice-delivered fluoride varnish is being questioned - as in the recent large randomised control trial from Northern Ireland (Tickle et al., 2017).

The hypothesis that the observed results were due to oral health conscious parents/carers who were motivated to actively regularly attend Childsmile dental practice appointments, rather than it being the result of the interventions delivered by the dental team, was tested to some extent in this thesis. The results provided no evidence to suggest that those children who were receiving fluoride varnish applications at every Childsmile Dental Practice Contact had any further or enhanced reduction in the risk of Caries Experience, in comparison with those children that had never received an application and had had the same number of contacts. Not only does this support the motivated parent/carer hypothesis, but it also questions further the additional clinical benefit of fluoride varnish application. This large population-based thesis cohort therefore corroborates the similar findings of the trial in Northern Ireland, which showed no preventive effect of fluoride varnish applications in the dental practice setting, when compared to routine preventive advice among children of the same age and over the same exposure time as the thesis analysis (Tickle et al., 2017).

5.3.3 Explanations and Interpretations of the Supervised Toothbrushing Component

Reach of Supervised Toothbrushing Component

The supervised toothbrushing component was intended to be delivered universally to all children who were attending nurseries. At the overall nursery participation level, a near universal coverage (89%) was observed. This was in keeping with the published monitoring reports where it is reported that 96% of nurseries (establishment-level) in 2015 and 97% in 2018 were participating in the programme (Central Evaluation & Research Team, 2018) and showed the programme was being delivered as envisaged in the nursery setting. When greater than two years (i.e. into a third year) of child level participation is assessed within the cohort, the level of participation dropped to around only half of the children (57%) having continuous participation in the supervised toothbrushing programme. The explanation for this lower level is two-fold, firstly at the time of the cohort very few children had places in nursery schools below three years of age - i.e. would have been in a nursery school placement for more than two years (Scottish Government, 2016d), and secondly while there was some toothbrushing in primary schools this was not universally provided across Scotland.

Supervised Toothbrushing Component Association with Caries Experience

The previous ecological area-based study suggested that the Childsmile supervised toothbrushing in Scotland was helping to drive the reduction in the trend of dental caries observed in Scotland, and that there was a stronger association between the uptake in toothbrushing and the reduction in caries among children from most deprived areas (Macpherson et al., 2013a). The thesis results further supported these previous findings. In addition, this thesis provides new evidence to suggest that the impact of the supervised toothbrushing programme in reducing risk associated with caries experience of children from the most deprived communities is strongest and also apparent with only one year of participation in the programme.

Unlike DHSW and Childsmile Dental Practice Contacts, there was an interaction between SIMD and number of years toothbrushing. Essentially, the results suggest that supervised toothbrushing is having a greater and earlier impact (after one year) on reducing the odds of dental caries experience in children from more socioeconomically deprived areas.

Children living in the 40% least deprived areas and participating in the toothbrushing component had no significant differences in caries, regardless of duration (time consented), when compared to their non-participating peers. One possible explanation for this is that children living in the most affluent areas are more likely to already be regularly toothbrushing at home (Levin and Currie, 2010), and therefore the addition of a further toothbrushing occasion in the day (in nursery) would not contribute so much of an additional benefit. Conversely, the positive finding that children living in the most deprived areas benefited most, with a reduced risk of caries associated with participation in supervised toothbrushing, might be due to more irregular brushing at home (Tsakos et al., 2015).

5.3.4 Explanations and Interpretations of the Dental Nursery and School Fluoride Varnish Component

Reach of Nursery and School Fluoride Varnish Component

The Nursery and School Fluoride Varnish Component was targeted based on socioeconomic deprivation level of the home postcodes of the children on the rolls of the education establishments. The analysis of the reach of the nursery and school fluoride varnish component showed that around 50% of the whole population cohort had received at least one fluoride varnish application. It also indicated that the delivery of this component was highly associated with child level socioeconomic deprivation status in favour of children from the most deprived backgrounds (75% of SIMD 1 children in comparison to 23% of SIMD 5 children) i.e. it was targeted as expected, and indeed went well beyond the 20% of the population minimum initially envisaged by the Scottish Government.

The Nursery and School Fluoride Varnish Application component is delivered via nurseries and primary schools and includes all children on the roll of the participating establishments. It does not and (and cannot) target at the individual child level, therefore it is inevitable that targeted establishments will contain children from less socioeconomically deprived areas. However, the analysis of the delivery of the nursery and school fluoride varnish indicated that the delivery of this component was highly associated with child level socioeconomic deprivation status in favour of children from the most deprived backgrounds. The targeting approach is therefore largely in-keeping with what was envisaged. Moreover, it should be noted that the overarching aim of the Childsmile Programme was to ensure that as many as possible of the children from the most deprived fifth of the Scottish population residing in SIMD 1 were included, and in fact 75% actually were. This was achieved because health boards included more than 20% of the nurseries and school age children in their fluoride varnish component.

A political decision was made by the Scottish Government to implement the targeted components of the Childsmile programme in such a way that each health board should target a minimum of 20% of their nursery and school population, based on their local deprivation scores i.e. utilising local health board SIMD rather than the national SIMD. There was also added pressure when the delivery of Childsmile fluoride varnish in nurseries and schools became a performance target (Scottish Government, 2012c). These were known as HEAT Targets (covering Health improvement, Efficiency, Access to treatment, and Treatment domains across the health service). The dental HEAT target related to fluoride varnish application stated that 'At least 60 per cent of 3 and 4 year old children in each Scottish Index of Multiple Deprivation (SIMD) quintile to receive at least two applications of fluoride varnish (FV) per year by March 2014'.

The performance of health boards was monitored and published against the HEAT target – so there was a lot of pressure on delivering fluoride varnish, and this drove much of the Childsmile planning and activity locally. Health boards were funded from the Childsmile budget only to deliver the nursery and school fluoride varnish programme to the most deprived fifth (20%) of children. There was also an expectation that to reach the 60% of each SIMD quintile / fifth this would largely be delivered via Childsmile Dental Practice activity. However, as the 2014/2015 target year approached, health boards were widening the targeting of the nursery and school fluoride varnish to cover more than the most deprived quintile / fifth as they realised that they had more 'control' over this intervention than the Childsmile dental practices as these practices were independent NHS contractors rather than part of the salaried service.

An evaluation of the efficiency of targeting of the programme by Brewster et al., (2013) had also shown that to ensure that most children from the most deprived SIMD areas (20%) are included in the programme, nursery schools located in the three most (60%) deprived SIMD fifths needed to be included in the programme. Brewster et al. also highlighted the limitation of targeting via health boards in terms of reaching children from the most deprived areas at the national level. Of the total children in the thesis cohort, 62% of the children had attended an establishment that had been targeted for fluoride varnish while they were in attendance, and 49% received at least one application. Even although the targeting is at a local level, the difference in the approach compared to the DHSW component (with widening the delivery to include around 50% of the population and targeting establishments over individuals) has led to greater reach to children from the most deprived communities in the fluoride varnish programme. The fluoride varnish component included much higher rates of children from the 20% most deprived national quintiles being targeted (89%) and actually receiving at least one application (75%).

There has been no change in the delivery of this component since the cohort endpoint (2014/2015). In 2015, 37% of children receiving at least one fluoride varnish applications were living in a national SIMD 1 area and in 2018 it was 36%. (Central Evaluation & Research Team, 2018). In the study cohort, 36% of children with at least one application were also living in a SIMD 1 area.

Nursery and School Fluoride Varnish Component's Association with Caries Experience

Although it appears that each of the Childsmile components were independently associated with reduced odds of caries experience, for the Nursery and School Fluoride Varnish component, the interpretation of this finding is complex. This finding was being driven by the inclusion of those children who were not targeted to receive the component in the model. This can explain why at the full cohort level, after the Model Two adjustment for the other three components, there was no change in the odds of caries experience regardless of the number of applications received, i.e. there was no association between fluoride varnish applications and a reduction in the odds of dental caries. As expected, those who were not targeted had a lower risk association with caries experience.

The odds were investigated separately by each SIMD category due to the significant interaction test. A reduction in risk associated with caries experience was found with increasing numbers of fluoride varnish delivered within nurseries and schools only amongst those children living in the second and third most deprived but not the most deprived (SIMD 1) areas, or in the least deprived (SIMD 4 and 5) areas. After the Model Two adjustment, this effect of the component was attenuated at the SIMD level, and a significant reduction now only observed within SIMD 2 for five plus varnishes, a small subgroup of 1,164 of the total 31,581 children in the cohort targeted (3.7%).

While the Cochrane systematic review of fluoride varnish shows a clear caries preventive effect in children (Marinho et al., 2013), a more recent updated systematic review is casting doubt over fluoride varnish effectiveness and cost-effectiveness (de Sousa et al., 2019). Moreover, a recent large randomised trial that was undertaken in dental practices with children initially aged two- to three-years-of-age and followed up for two years found a non-significant marginal benefit of fluoride varnish compared to preventive advice only (Tickle et al., 2017). Even more pertinently, the recently completed Childsmile embedded randomised control trial – "PT@3 - Protecting Teeth at 3" needs to be considered. PT@3 compared an intervention group receiving nursery fluoride varnish applications and supervised toothbrushing with a control group receiving supervised toothbrushing alone. The intervention group received fluoride varnish applications every six months in the nursery setting between baseline and 18 months. The preliminary results found only a modest and non-significant reduction in the worsening of $d_3$mft in the intervention group over the two year period in comparison with the control group (Wright et al., 2018). The final trial results are not yet published, but the preliminary findings show that the added effectiveness of fluoride varnish is uncertain. This chimes, to some degree, with the results of this thesis, where the reduction in caries was only observed in a very small fraction of the cohort.

In parallel, the thesis has also shown that there was no evidence to suggest that the children who were receiving fluoride varnish applications at every Childsmile Dental Practice Contact had any reduction in the risk of caries experience in comparison to those who had never once received an application regardless of the number of contacts.

No significant effect on dental caries risk was observed among the children from the most deprived SIMD quintile. The evidence from the PT@3 study was that there was no significant reduction in caries for children receiving fluoride varnish over and above supervised toothbrushing (Wright et al., 2018). It is therefore plausible that this was also the case for the children within the cohort, particularly for those living in the most deprived quintile, due to the almost universal coverage of supervised toothbrushing, which for children in SIMD 1 it was 94%.

There was also no effect of fluoride varnishing on dental caries risk among children from areas in the two least deprived quintiles. McMahon et al. (2011) showed much lower rates of dental caries by three years old, with children from SIMD 4 and 5 areas having caries prevalence of ten and five percent respectively. These low rates suggest that children from more affluent socioeconomic areas do not require fluoride varnish applications perhaps because of already established oral health behaviours driven by their more affluent socioeconomic circumstances (Pieper et al., 2012). The clinical guidance in Scotland is that higher caries risk children (defined to include those from SIMD 1 and 2 areas) should receive a fluoride varnish four times per year whereas all other children in Scotland (considered ‘standard’ risk) should receive it twice per year (Scottish Dental Clinical Effectiveness Programme, 2010). This was the evidence-based rationale for the Childsmile model of delivery of fluoride varnish across the programme (twice per year for all children universally plus two additional applications in nursery or school for the higher risk SIMD 1 and 2 children). Therefore, it may be that there is no additional benefit of fluoride varnish in nurseries if these lower risk children are already receiving it twice yearly at dental practices. However, this thesis did not look at the combined applications across locations and their associated odds ratios.

5.4 Further Discussion Points

5.4.1 Considering the Relative Importance of each Childsmile Component in relation to Caries Experience

Each of the individual Childsmile components were independently associated with a reduction in odds of Caries Experience. However, there was variation in the intensity of each component required to realise a significant reduction, and there are differences in the fundamental meaning of contact or engagement with each component during the cohort period. These categories were, for supervised toothbrushing – the number of years participating (or rather parent/carer consent to participate in toothbrushing); for the nursery fluoride varnish component - the number of fluoride varnish applications; while for both DHSW and Dental Practice – the categories were the number of contacts (although for dental practice contacts, the type of oral health prevention intervention received was also examined).

The categories (frequency levels) within each of the Childsmile components are not directly comparable with each other - given different meaning of data categories and the variable number of strata. For example, nursery and school toothbrushing consent covers participation in this component for the year (with a maximum number of two to three years), whereas the number of contacts in the practice can cover a five-year period and reach much higher frequencies (n > 10).

At the population level in the cohort, a child was required to attend a dental practice three times in order to have the same reduction in risk of a child that had been part of the toothbrushing component for two years or more. This, however, does not consider causality, i.e. who are the parents or carers of the children that are regular attendees and what were the enablers, their behaviours, or personal motivation levels towards oral health. Just fewer than 10,000 children had attended a dentist on three or more occasions yet almost 30,000 children (with close to 12,000 from the 20% most deprived areas alone) had been consented to the supervised toothbrushing component for two years or more. Therefore, while both components are clearly associated with a reduction in the risk of caries, the impact of supervised toothbrushing can be seen on a much larger scale across the population. There are also differences in the nature of accessibility of these two components: attendance at a dental practice requires much more personal active involvement and motivation in comparison to the day-to-day attendance at a nursery school where the intervention is routinely available with little or no involvement of the parent or carer required. Sally Macintyre in her review of what works and what doesn't work to address health inequalities highlighted a major barrier where interventions rely on people having to opt-in to receive it (Macintyre, 2007). Thus, the more an intervention relies on active motivation to be adopted, the less likely it is for success. While the supervised toothbrushing component required an opt-in consent, this was a one-off process at the enrolment of the child with the nursery, and there was near full consent within the nurseries participating, which itself was nearly all the nurseries in Scotland (Central Evaluation & Research Team, 2015).

5.4.2 Discussion of the association between obvious dental caries experience and sociodemographic characteristics

Of each of the sociodemographic characteristics that were available in the analyses (age, sex, and area-based socioeconomic deprivation), area based socioeconomic deprivation, measured by SIMD, was the most strongly associated with caries experience. This is in keeping with the literature which shows the near-predictive association of child dental caries experience and socioeconomic factors (Blair et al., 2013; Peres et al., 2019).

Oral health inequalities were observed in the study cohort, with children from the poorest areas having 45% of obvious caries experience, while children from the more affluent areas had only 16%.

Oral health has steadily improved at a population level since Childsmile was launched (Macpherson et al., 2018), without a widening of oral health inequalities, which was perceived as a potential risk at the outset of the programme (Shaw et al., 2009), and which drove the development of universal and targeted components (later coined by Marmot (2012) as proportionate universalism). It could be concluded that the proportionate universalism approach of the delivery of the Childsmile components has to some degree been successful in ensuring that similar levels of oral health improvement have been observed across the Scottish five-year-old population across all deprivation groups. However, the gradient of inequalities in child oral health in Scotland has been stubbornly persistent (Macpherson et al., 2018). Mackenbach (2011) has argued that public health programmes can only go so far in terms of reducing inequality, and that wider socioeconomic policy / reform is required to tackle underlying inequalities. He goes on to propose that success can be measured in avoiding widening relative inequalities when overall population health is improving - i.e. avoiding more rapid or greater improvement among more affluent groups.

The magnitude of inequalities (absolute differences) in Scotland may be even wider than that reported in this thesis. This is due to two factors. The first is that higher rates of children from the most deprived area can be absent on the day of inspection (Scottish Government, 2018a). In the case of the study cohort, approximately 9% of the SIMD 1 children were excluded for not having a Basic NDIP, whereas for SIMD 5 children it was only 6%. The second factor is that the inspection does not include children attending private fee-paying schools. These schools will obviously be largely attended by children from the least deprived quintiles. Therefore, it could be concluded that many of the children at both the higher and lower end of the socioeconomic risk scale are not included in the NDIP reports and resultantly in the thesis, which could also be considered a limitation of the thesis data.

5.5 Limitations of the Study

It is becoming increasingly apparent that in big data studies, including population-based studies using national-level routine administrative data (such as in this thesis), hold much promise in terms of potential power to definitively assess the burden of epidemiological problems without concerns of representativeness. However, it is also becoming apparent that there are many limitations that should lead to some caution when interpreting the findings of this evaluation. These limitations come in several forms including; the prolonged difficulties and challenges in navigating multiple information governance approval processes, gaining access to and transferring data, and in managing and linking large datasets from different sources. The main limitations are associated with the nature of data and the variables within these datasets and the quality and completeness of linkage methods. In addition, a number of analytical limitations are discussed.

5.5.1 Data Limitations

5.5.1.1 Data Linkage

Data linkage, especially when bringing together many datasets is not without its limitations. It has been suggested in the past that approximately 15% of true links are missed (Kendrick and Clarke, 1993). For longitudinal studies such as this one, the chances of error increase as families move home, change name, or typographical errors are made at the point of data entry (Grzeskowiak et al., 2013). Many of the datasets in this thesis study contain multiple records for individual children and therefore as the number of records for an individual child in the cohort increases, so does the risk that a record will not be linked and then the data profile for a child would be incomplete. A systematic review of probabilistic data linkage has reported that the accuracy (records that were correctly linked) ranged from 74% to 98% while the specificity (records that were correctly unmatched) ranged from 99% to 100% (Silveira and Artmann, 2009). As the datasets uploaded into the Safe Haven were reflective of the published reports that had used the same, but otherwise unlinked datasets, one can surmise that even after probabilistic linkage, the risk of errors in the data arising from this method was minimal.

5.5.1.2 Area-Based Deprivation

Individual household level socioeconomic index data were not available for the children in the cohort and therefore small area-based socioeconomic deprivation (measured via Scottish Index of Multiple Deprivation – SIMD) of the child's home postcode was used instead. Individual household socioeconomic status will vary across households within an area which would be grouped within the one level of area-based deprivation (Macintyre et al., 1993). While this 'ecological fallacy' concern that area-based indicators makes assumptions on individual socioeconomic status, area-based indicators can capture common community domains of multiple deprivation such as transport, access to services, and levels of unemployment that collectively impact on individuals (Macintyre et al., 1993; Pearce, 2000).

5.5.1.3 Data Quality

The role of the researcher in undertaking quality checks in a Safe Haven is limited due to a lack of personal identifiers being available, so cross referencing with the original record is typically not possible. However, the data available (including child date of birth) and methods employed in this thesis allowed for the identification of major data errors. This derailed the thesis significantly and required major methodological re-development to build an accurate analytical cohort. Once these initial data errors had been rectified, additional quality checking methods were developed based on the availability of the date of birth variable (which is a rarity in data linkage studies because of the potential disclosive nature of this variable). Following robust data quality and completeness procedures, a study cohort was developed which was an accurate and high-quality dataset that could meet the needs of the Childsmile evaluation.

5.5.1.4 Limitations of Dental Health Support Worker Data

The DHSW component was measured as a 'contact' which does not account for the variation in the delivery or the intensity of the contact. For example, it is assumed that every DHSW contact would have included some measure of oral health advice including toothbrushing and dietary advice, regardless of whether or not the DHSW had indicated on the contact record that they had delivered either one or neither of these interventions. Referring to the description of these variables in Section 3.4.1.4, toothbrushing advice was only recorded as delivered on 78% of occasions, and dietary advice on 75% of occasions. Analysis of the nature of the DHSW contact interventions could be conducted as further research.

5.5.1.5 Limitations of Supervised Toothbrushing Data

An internal unpublished Childsmile programme monitoring survey conducted in 2012, when most of the children in the thesis cohort would have been aged between two and three years, indicated that 81% of participating nurseries and 72% of children in Scotland on the nursery roll were brushing on the day of the survey. The most common reason for a nursery not brushing on the day of the survey was because the class was participating in external trips or events. In some nurseries, it was reported that children who were only in at certain times of the day would not always participate in toothbrushing. This was because supervised toothbrushing could sometimes take place at the same time of the day, and some children who may only attend nursery in the morning or afternoon, could sometimes miss out.

It should be noted, that from 2016/2017, negative consent (i.e. opt out consent) to this component was introduced and therefore individual consent is no longer required (Central Evaluation & Research Team, 2017). This means that the child level data that were available for this cohort study was conducted in a rare window, with the opportunity to analyse at the individual child-level, the length of time that they had been consented, and by proxy, were participating in the supervised toothbrushing component.

5.5.1.6 Limitations of Dental Practice Data

When analysing the Childsmile Dental Practice Contacts, it was assumed that at each contact, the child had received both toothbrushing instruction and dietary advice even if one or neither had been recorded as being delivered. A review assessing chairside interventions that were designed to reduce dental caries reported that when dietary advice is delivered as an oral health intervention, it was predominantly delivered as combined advice alongside toothbrushing instruction and it was concluded that it can be difficult to distinguish which of the two interventions were driving any observed improvements in oral health associated with regular dental attendance (Harris et al., 2012). Although, as discussed above there could be alternative (family related) explanations associated with regular attendance that are independent of any interventions received within the practice.

5.5.1.7 Limitations with Outcome Measure

The use of obvious caries experience as a binary measure for caries in this study has its limitations. If a child in the cohort had caries experience, the severity of the caries is unknown e.g. is there caries in one tooth or ten? The indices of $d_3$mft (decayed missing and filled teeth) or $d_3$mfs (decayed missing or filled surfaces) would have provided data on the severity of caries. As the NDIP Detailed Inspection alternates yearly between Primary One and Primary Seven, $d_3$mft data were not available for five-year-old children in 2015. Even if it had been, it would only have contained a sample of approximately 20% of the population and therefore would not provide the scope and capacity which this full population study has been able to achieve.

Moreover, the child's caries status was only available at the endpoint of the study. In the past there has been a three-year-old NDIP inspection but this was for children from an earlier cohort year and was for a sample of children from the NHS Greater Glasgow & Clyde health board only (McMahon et al., 2011). Ideally, it would be good to have an additional intermediate time-point outcome of caries at three years of age to explore further the impact of caries progression around the delivery of different components of the Childsmile programme.

The outcome measure was only available for children attending a local authority school. Less than 5% of the population attend a private school in Scotland (Scottish Council of Independent Schools, 2016), therefore the outcome measure could have potentially been available for 95% of the Scottish five-year-old population. As it transpired, 88% of the population received a Basic NDIP inspection, and after cleaning the data, 85% of the population remained within the cohort. Following detailed assessment of those excluded – there was no bias observed related to the make-up of the final analysis cohort.

5.5.1.8 Limitations of Data Available

The thesis analysis cohort was built from linking routine administrative data. As such they did not include all the data fields that an ideal study assessing the impact of the Childsmile programme and its components would benefit from.

There were no intermediate behavioural or psychosocial factors at the individual family level that could have been included in models to help understand the pathway between Childsmile components and the oral health outcome.

5.5.2 Analytical limitations

The main analytical limitations are that this analysis was performed on a single NDIP inspection year cohort (2014/2015) as the programme had only just been rolled out nationally, and that this is only the first and preliminary investigation of the impact of the different components on child oral health outcomes. It is therefore not the definitive findings of the effectiveness of the programme or components, rather it provides initial assessment of the relationship between contact with components of Childsmile and risk association with caries at five-years-of-age. These analytical limitations also include the uncaptured confounders and explanations associated with data limitations (including data availability) discussed above.

5.5.2.1 Cohort Period

The main analytical limitation is that this analysis was of one NDIP year cohort. The national roll-out of Childsmile began in 2010/11 and the analysis was undertaken using data from the 2015 Basic Primary One NDIP. Therefore, the study cohort included the first children that had the potential to receive each of the Childsmile components from birth. It was possible that the delivery of each of the components will have become more refined with time and therefore the delivery of Childsmile experienced by the study cohort may be different to those children experiencing Childsmile subsequently.

5.5.2.2 Regional Analysis

As part of the Childsmile logic model, there is ongoing process-evaluation being undertaken. This includes the collection of qualitative data relating to differences in the methods of delivery of each component of Childsmile depending on the region or health board (e.g. data on Childsmile workforce, organisational structures, and local resources). These additional regional or health board data could complement the individual cohort data (analysed in this thesis). Multi-level analyses approaches could be used to analyse individual and area data investigating whether there are geographical differences or variations in outcome and programme delivery.

5.5.2.3 Alternative analytical approaches

There was no opportunity to conduct a true natural experiment or a quasi-experimental study (e.g. via a stepped wedge design), which could have been possible had the Childsmile components been rolled out across the country with different start dates for each of the health boards. However, there was national roll out in all boards of the Childsmile programme from 2010/11 (Macpherson et al., 2019b; Macpherson et al., 2019a).

To help understand the thesis finding of each component's association with caries risk, further detailed analyses are warranted (including within subsequent cohort years). Alternative analytical approaches could include exploring the relative impact of the interventions via for example population attributable fraction (PAF). The population attributable fraction (PAF) is an epidemiological tool widely used to assess public health impact of exposures in population. It is commonly used to investigate the population risk factors associated with disease, and it could similarly be used to assess the impact of interventions on disease outcomes in a cohort (Mansournia and Altman, 2018). Others propose a 'difference-in-differences' approach as used in the recently published evaluation of Sure Start, a complex intervention in England designed to improve a range of child outcomes including health, social and educational (Cattan et al., 2019).

Further in-depth analysis of the interventions delivered within the Childsmile components could also be undertaken. The thesis analysed the impact of Childsmile components at a high-level - assessing contact or participation in each component. However, there was more detail (activity) underpinning this contact or participation – some of which we investigated e.g. whether the dental practice contact included fluoride varnish, but there are further intervention-related data (e.g. in relation to the DHSW contacts) that could be explored in future analysis.

5.5.2.4 Timing of Interventions

The thesis analysis did not take into consideration the precise timing (in relation to age or calendar time) of when a contact or treatment took place. For example, did a child with four dental practice contacts have all four contacts in the first two years of their life, or was this spread out over a five-year period, or even more so, were they clustered into the two years prior to the child's five-year-old NDIP inspection? The spacing of dental practice contacts was not assessed, however, the DHSW contacts would likely have been clustered to the very early years, while the toothbrushing intervention would have been regular and consistent (albeit only on school days, and not on weekends or holidays), while the fluoride varnish component was likely spaced as the nursery and school fluoride varnish component protocol indicates the two annual visits should be delivered in different academic terms.

It is reasonable to suspect that combinations of component 'contacts' and relationship with the timing of the delivery of each component could impact on caries experience. The measurement of the time of the contact in comparison to the endpoint was beyond the scope of the thesis. However, the dose response of each of the components (excluding the DHSW component), suggests that the contacts were more likely to have been spread over time, rather than to have been clustered together.

5.6 Strengths of the Study

5.6.1 Population Coverage

Due to the high population coverage of the National Dental Inspection Programme (Basic inspections for the outcome measure indexed to CHI database), it can be confidently stated that the cohort was an accurate reflection of the Scottish population including representative distribution by sex, and socioeconomic backgrounds, and from all areas across Scotland. The large cohort size meant that there was sufficient power to test for statistical interactions and to undertake sub-group analyses where appropriate. It also limited the risk of selection bias. Caution, however, is required with studies this size when using the p-value to measure significance, and within this study, the 95% confidence interval was more often utilised as the measure of significance.

5.6.2 Routine Administrative Data and Data Linkage

Making use of pre-existing routine administrative health service data was also unobtrusive as the participants in the study did not need to be contacted.

Secondary use of routine data is also efficient in terms of reduced costs and time associated with collecting study data – however, the process is not without research costs and takes a long time to access data. The quality and completeness of the data used in this study were extremely high as described in Chapter Two of this thesis. The datasets used in the study were an accurate reflection of data that has appeared in published reports. For example, in the cohort data, the proportion of A, B, and C letters distributed to families, which were the building blocks of the outcome measure of caries experience used in this thesis, accurately matched that in the published reports (ISD Scotland, 2015). The supervised toothbrushing, nursery and school fluoride varnish, and the majority of DHSW contact records were collected via the HIC Childsmile IT system. HIC run regular quality control reports that are provided to regional Childsmile teams so that any outstanding quality issues can be corrected as close to the point of data input as possible (e.g. invalid postcodes that do not link to a SIMD lookup file and dates of birth that do not match the CHI number). This minimised the risk of the person entering the data (e.g. the DHSW contacting the family), from ‘forgetting’ what happened at a contact, thus maximising the accuracy of these data. For clinical governance and child protection issues, it was also essential that DHSWs maintained an accurate record of all contacts (both successful and unsuccessful), therefore there were strong drivers for robust data recording. The data used for measuring Childsmile dental practice contacts, which were extracted from the MIDAS dataset, are primarily used to calculate payments for dental practitioners for their involvement in Childsmile as well as for other NHS treatments they may have delivered. Therefore, there was a financial incentive for dental practices to ensure that these data were recorded accurately.

The availability of the Community Index Number (CHI) in Scotland allows for multiple routinely collected administrative datasets to be linked. It is estimated that 96% to 99% of the Scottish population have been assigned this unique identification number (Pavis and Morris, 2015). The CHI number allows individuals to be linked across time and location via both health, and non-health datasets such as educational datasets (Clark, 2015).

Both the MIDAS and NDIP datasets did not routinely record or include CHI on their records. CHI therefore had to be added (or ‘seeded’) on to the datasets by linking them to the CHI database using patient identifiers (forename, surname, date of birth, sex, and home postcode) by probability matching methods. An assessment of the data linkage quality in Scotland of matched pairs of records reported that rates of false negatives (pairs of records for the same person in both databases that did not link) and false positives (pairs of records that were linked but were two different people) only occurred in three percent of linkages (Kendrick and Clarke, 1993). This suggests that the quality of data linkage in Scotland is high. The datasets that were provided for this study included datasets where the CHI was already pre-populated (i.e. Child Health Surveillance) and therefore CHI completeness for these datasets was expected to be 100%. For those datasets that were to be linked by means of probability to the CHI database (NDIP, MIDAS, Fluoride Varnish Dataset, and Toothbrushing Consent), only a very small proportion of records (<1%) could not be linked to CHI.

There were some limitations in the data as discussed; however, the strengths of the population-level data and in the data linkage methods (once the additional quality completeness checks were developed and performed) created a robust cohort. This cohort enabled an analysis that could evaluate the associations of the four main components of the Childsmile programme on obvious dental caries experience outcomes among five-year-olds in Scotland in a single NDIP year cohort.

5.7 Conclusions

To the author's knowledge, this is the first outcome evaluation of a complex national population child oral health improvement programme using data linkage of individual child health records from multiple routine administrative datasets. This section will present the conclusions drawn from the findings of the thesis research in relation to meeting the thesis objectives, which were to:

1. Develop an analysis cohort from linking multiple routine administrative datasets to evaluate the impact of the components. Part of this objective was to assess the feasibility of undertaking this complex work.

2. Assess whether the Childsmile programme with its universal and targeted components were being delivered as envisaged and whether the delivery varies by socioeconomic status of the child population.

3. Examine the association between obvious dental caries experience and the sociodemographic characteristics (age, sex and area-based deprivation) of a five-year-old study cohort.

4. Assess the impact of each of the individual components of the Childsmile programme on obvious dental caries experience and whether there is variation of the impact by sociodemographic characteristics.

5. Investigate the independent effect of each of the Childsmile components over and above the other interventions and explore the relative contributions of each of the components of Childsmile on obvious caries experience within both the whole child population and for children living in the areas of highest deprivation.

The overarching aim of this thesis was to assess the impact of the main components of the Childsmile programme on the obvious dental caries experience of five-year-olds. This research was required as although there had been improvements in child oral health since the launch of Childsmile in 2006, the association of each of the Childsmile components with obvious dental caries experience was unknown.

5.7.1 Developing a data linkage cohort

The objective of developing a data linkage cohort was completed... eventually! This process was not without significant problems and delays. Complex information governance approval processes were navigated. Data dictionaries for multiple data sources that were related to child dental services, the Childsmile Programme, and child oral health were created. These data dictionaries are a resource that will also support future researchers in specifying data analyses. Variables were selected that would capture the delivery of the Childsmile components. Datasets were indexed using the unique NHS identifier – the Community Health Index (CHI) number – which was then removed following linkage, with only a unique (non-identifiable) child study ID variable remaining. Secure data access via the National Safe Haven was pilot tested, and the systems and protocols were improved as a result. Preliminary quality and completeness checks showed fundamental problems with the source data indexing, and processing. The data sourcing and indexing processes were repeated. The quality and completeness protocols that were developed initially were rapidly run with reassuring data completeness relative to expected published reports. Following this, an individual child-level analysis birth cohort was created by linking NDIP child oral health outcomes to Childsmile component variables. This cohort was able to run the overarching analyses to answer the thesis research questions.

5.7.2 Delivery of Childsmile components as envisaged

The delivery of the programme was being delivered mostly as envisaged in terms of the targeted and universal components. However, there remains room to improve the reach of the components. The delivery of the universal supervised toothbrushing programme overall is high, with children from more deprived areas having slightly better participation.

Petersen and Kwan (2004) proposed that oral health improvement interventions should be regularly monitored and evaluated, and if they are not working as intended then they should be modified. The findings that Childsmile is being delivered to some extent as envisaged (in terms of universal reach and targeting) is testament to the ongoing monitoring (Central Evaluation & Research Team, 2015) and evaluation of the programme since its launch in 2006 (Turner et al., 2010). Data monitoring systems have enabled the Childsmile programme to adapt and evolve as it has been developed and rolled out. This is not to say the delivery of Childsmile is perfect or fully optimised. This thesis highlights that further focus could be given to improving the reach and targeting of the components of the programme. Issues that needs attention include the DHSW component to ensure that children potentially most in need are reached, and to the fluoride varnish in nursery and school with coverage way over the intended 20%.

There have been marginal improvements in the overall coverage of the dental practice component since 2015. For the nursery and school fluoride varnish component additional resources have already been allocated by the Scottish Government to extend their coverage of this component (Scottish Government, 2016a). From 2017 onwards, these additional funds will have been largely allocated to the health boards with the greatest burden of deprivation such as Greater Glasgow & Clyde, and Lanarkshire. This change has been introduced originally in response to Childsmile evaluation concerns about targeting based on local health board rather than national SIMD, but ahead of the thesis findings that further questions the effectiveness of the fluoride varnish programme in nursery and school.

For all of the four components, there has been no substantial changes in their reach by SIMD since the end of the thesis cohort to present (Central Evaluation & Research Team, 2018).

5.7.3 Burden of dental caries in the cohort and impact of the Childsmile programme

The Childsmile programme has been associated with reducing risk of dental caries in five-year-olds in the Scottish population. Oral health inequalities in the cohort were wide, with the difference in dental caries between children from the most and least deprived area being 30%. Males were also at a slightly higher risk of dental caries although the absolute risk difference was 2%. Dental caries progression was also related to age with the difference in dental caries rising by 3% each year, as the children in the cohort aged from four- to six-years-of-age (at the time of the NDIP inspection).

5.7.4 Impact of Childsmile programme on child dental caries experience

There was evidence to suggest that DHSW contacts were associated with a reduction in the odds of obvious caries experience when the child was contacted only once. This reduced risk disappeared if the child received additional contacts, which suggested that although there has been some success in DHSWs identifying children at a higher risk of obvious caries experience, the delivery of this component in terms of reducing the risk of caries for children at a higher need was less clear.

Attendance at a Childsmile dental practice was associated with a reduction in odds of obvious caries experience, with a clear dose response observed as the number of contacts increased, and no variation observed across the deprivation categories. It is suggested that regular attendance at a dental practice may be a proxy for good oral health behaviours in the home/family and that the parents attending these contacts are already enabled or motivated towards caring for their child’s oral health. This is reinforced by the fact that benefit of practice-delivered fluoride varnish application, over and above regular attendance at a dental practice was not reducing the risk associated with caries development.

Supervised toothbrushing was most effective at reducing the odds of dental caries when a child was living in an area of high deprivation, with the effect increasing the longer these children had been consented into the programme. For the children from the least deprived areas, there was no effect on the odds of caries experience observed regardless of the length of time that they had been participating in supervised toothbrushing.

The evidence presented in this thesis in relation to the nursery and school fluoride varnish component shows an initial independent effect, however, when those not contacted are taken into account, there was no overall effect, and reduced odds of developing caries only emerges among a very small number of children from SIMD 2 areas who received five or more fluoride varnish applications.

5.8 Recommendations

The recommendations from this thesis have been organised into two sections – those that are related to further research, and those that are directed towards the Childsmile programme policy and practice. The following recommendations should be considered with the caveat that the analyses only included children with five-year-old dental caries outcomes in 2014/2015.

5.8.1 Recommendations for Further Research

The recommendations for further research cover both future work to continue to evaluate the Childsmile programme, and also related data linkage epidemiological research using routine administrative data more generally.

5.8.1.1 Repeated / updated analyses

- An updated linkage study using multiple years of more recent data would allow further assessment of whether or not there has been a change or improvement in the delivery of the Childsmile components, and in relation to their impact on dental caries outcomes. The more recently published NDIP reports show an ongoing improvement in the dental caries prevalence of five-year-olds overall in Scotland and in each SIMD group (Macpherson et al., 2018). This further analysis will enable time (years) to be included and assess whether the improvements observed in caries has been influenced by the programme. This work is currently underway, and the thesis author has led the specification of the data updates and in gaining the NHS Scotland Information Governance approval process via the Public Benefit Privacy Panel (PBPP). Data are expected to be available later this year.

- Alternative approaches to analysing these data could be undertaken in future work - including for example difference-in-difference econometric analyses (Zhou et al., 2016; Wing et al., 2018) and approaches as discussed in Section 5.5.2.3.

5.8.1.2 Longitudinal and inequality analyses

- As part of the analysis of the refreshed cohort, longitudinal analyses of children for whom there are NDIP data available at both five- and 11-

year-old time points should be undertaken to measure the long-term effects of Childsmile on reduced risk of obvious caries experience. Similar approaches to those adopted in the analysis of the New Zealand Dunedin birth cohort could be undertaken (Thomson et al., 2004). The Childsmile birth cohort is limited in terms of not having parental/child behaviour data, although there are some possible related or proxy variables (such as breastfeeding data) that could be examined. In addition, more detailed analysis of socioeconomic factors including changing SIMD (i.e. social mobility) could be undertaken following deprivation analysis guidance (National Services Scotland, 2017) and utilising more sophisticated analysis of absolute and relative inequalities (Blair et al., 2013).

- Inequality analyses could also extend to evaluation of geographic variations including urban and rural differences, which could also assess the potential variations in delivery/implementation of Childsmile across the health boards of Scotland. It has previously been shown that five-year olds from urban areas have poorer oral health than their rural peers (Levin et al., 2010). These inequalities could be socioeconomically driven but could also be related to how the Childsmile programme and services are configured across the country.

5.8.1.3 Other Dental Health and Dental Health Service Outcomes

- Analyses of other dental health and dental health service measures for Childsmile should be undertaken. These include dental extractions under general anaesthesia – which is still the most common reason children have an elective hospital admission in Scotland (ISD Scotland, 2017) An earlier descriptive analyses of these data shows a decreasing trend (Scottish Government, 2012b).

- Further analysis of the primary care dental practice (MIDAS Management Information and Dental Accounting System) could be undertaken to assess in detail the patterns of ongoing attendance as an intermediate outcome, to investigate primary dental care treatments (including restorations and extractions). Other data available on MIDAS include information on the dental practitioner such as age, sex, time since qualified, location of practice, etc. These data could be analysed to provide insights into the impact on practitioner and practices following the introduction of a child health improvement programme into the primary care contract.

5.8.1.4 Wider Health and Social Outcomes

- The impact of Childsmile on childhood obesity (measured via BMI) and recorded in the Child Health Surveillance school system could be investigated (including the inter-relationship between dental caries and obesity outcomes). This work is already underway by another PhD student (Ryan Stuart) in the University of Glasgow.

- The under-explored interplay between socioeconomic factors and ethnicity in terms of assessing the inequalities in child oral health could also be explored within this data linkage work. Pioneering work led by the University of Glasgow Community Oral Health Group linked data from health and education records (Clark et al., 2017). This work paved the way to pick up important data fields captured on the education records but not on the health records. Ethnicity data have recently been linked in from this source and a series of projects investigating the role of ethnicity with dental caries prevalence, dental service access, along with the reach of the Childsmile programme is currently underway by another PhD student (Ahmed Mahmoud) in the University of Glasgow.

- Similarly, work investigating the oral health and impact of Childsmile on other vulnerable groups including looked after children (McMahon et al., 2018) and children with additional support needs is planned.

- Through the education and health data linkage, there is also the possibility of exploring the impact of Childsmile on educational outcomes (including school attendance). Poor school attendance and poor school performance was found to be associated with dental caries experience in a recent systematic review and meta-analysis (Rebelo et al., 2019) – albeit in the relatively small and moderate quality studies that were included.

5.8.1.5 Economic Evaluation

- A full economic evaluation of the components of Childsmile is required to determine the relative costs and benefits of each component of the programme. This work could build on the cost methods developed in the ecological economic evaluation of the nursery and school toothbrushing programme (Anopa et al., 2015) which found that for a cost of £1.8million per year from 2001/2002, an estimated savings of £4.7million by 2009/2010 could be realised.

5.8.2 Recommendations for the Childsmile Programme

The following sections list the recommendations for policy and practice for the Childsmile programme by the individual components.

5.8.2.1 Dental Health Support Workers Component

DHSWs should continue to direct those children with a lower risk of caries experience to a dental practice after an initial contact and offer additional support to those families that they deem to be at higher risk, although the delivery and implementation of this component of Childsmile could be improved. Other studies (Hodgins et al., 2018) have been undertaken within the Childsmile evaluation investigating the role and effectiveness of the DHSW in linking families (particularly those from the most deprived areas) with primary care dental services. However, this thesis was the first to assess the impact of contact with DHSWs in relation to dental caries outcomes, which shows some promise in reducing caries experience.

This thesis demonstrated a gradient of targeting to children from the most deprived communities, and that only 30% of children from the most deprived areas had any contact with a DHSW. This could have been a function of implementation via local health board SIMD categories rather than national SIMD targeting. Additionally, Health Visitors have deemed children from other SIMD areas to have been at increased risk, which was also appropriate given the socioeconomic gradient and the ecological issues associated with assigning the area-based SIMD measure to individuals.

Therefore, it is clear that the targeting and implementation of the DHSW resource needs to be reviewed by Childsmile stakeholders with a view to further improving outcomes. This review should take into account the full body of evidence that has been collated from the Childsmile evaluation studies undertaken on the DHSW component. There would be merit in broadening this review to consider the evidence in relation to improving or changing the nature of the ‘advice’ interventions delivered by the DHSW (which was beyond the scope of this thesis). These interventions currently include tailored toothbrushing instruction, dietary advice, and linking with dental practice and other community initiatives. However, the contribution of this thesis in terms of identifying the need to improve targeting to reach those children from the most deprived communities, and in highlighting the particular challenges among those children at greatest risk (identified in the thesis as having two or more DHSW contacts) should be a priority area for the Childsmile Programme DHSW review.

The Childsmile Programme is now working with NHS Education for Scotland (the national health service training organisation) to amend the DHSW training regarding the nature of support required for children at greater risk including for example on social prescribing.

5.8.2.2 Childsmile Dental Practice Component

The finding of this thesis that increasing regular Childsmile Dental Practice contacts was associated with improved child dental caries outcomes should be taken as an important ongoing intermediate goal of the Childsmile programme – i.e. regular and frequent dental attendance is a good proxy for measuring or capturing general / family oral health behaviours and motivation, and an intermediate marker of success of DHSW activity.

Currently, national routine statistical monitoring of child dental practice attendance is via ‘dental registration’ (which can indicate a single visit) and via ‘dental participation’ (which indicates at least one attendance in the preceding two-year period) (ISD Scotland, 2018a). These indicators are perhaps inadequate in terms of an outcome goal that would be associated with improved dental health e.g. a single attendance or a small number of irregular attendances at a dental practice that does not confer reduced dental caries risk.

A more regular (e.g. annual attendance) measure – particularly for young children should be considered by both the Childsmile Programme in their annual headline monitoring reports and by ISD in routine dental care statistics.

This thesis shows substantial reductions in the risk of caries that was associated with multiple dental practice contacts, although does not fully explain this relationship. The thesis findings also support the increasing body of international literature and robust evidence (Tickle et al., 2017; de Sousa et al., 2019) which questions the caries preventive effect of fluoride varnish. It would still be premature in the development of Childsmile to remove fluoride varnish from the practice-based preventive interventions – although there would be merit in revisiting and reviewing the evidence base generated from the Childsmile evaluation in the context of the international literature.

The policy and practice context in Scotland includes the recently updated published Scottish Dental Clinical Effectiveness Programme (2018). Clinical guidelines continue to recommend fluoride varnish twice per year for all children increasing to four times per year for those children at the highest risk. It was also only relatively recently that a specific payment item on the NHS primary dental care contract (Scottish Government, 2011b) was implemented. Elsewhere within the Childsmile evaluation, the delivery of fluoride varnish to children in dental practice has been has shown to be highly variable (Ross et al., 2018) and work is ongoing to bring quality improvement methodologies to enhancing fluoride varnish and other preventive interventions within Childsmile.

The national Oral Health Improvement Programme for Scotland (Scottish Government, 2018b) includes plans to reform the primary care contract to ensure it is more preventive focused and includes risk-based recall intervals. It would be important that the findings of this thesis are fed into this process.

5.8.2.3 Supervised Nursery and School Supervised Toothbrushing Component

This thesis has shown that the Supervised Nursery and School Toothbrushing component of Childsmile has been associated with a reduced risk of caries – particularly for children from the most deprived communities, and with no impact amongst children from least deprived areas.

One interpretation of these findings could be to make the recommendation to deliver the toothbrushing programme to nurseries and schools serving children from the most deprived areas. Indeed, this is the proposed recommendation being taken forward by Public Health England and outlined in the Department of Health and Social Care for England Consultation Green Paper *Advancing our health: prevention in the 2020s,* which is currently consulting on the aim of rolling out a school toothbrushing scheme in pre-school settings ‘to reach the most deprived three- to five-year-olds in all areas of the country ... by 2022’ (Cabinet Office and Department of Health and Social Care, 2019).

However, in Scotland it has been shown, as part of the earlier development evaluation of Childsmile, that to ensure that the most deprived 20% of children are included via a nursery or school-based targeting approach, 60% of nurseries and schools need to be included (Brewster et al., 2013). Furthermore, previous ecological studies demonstrated that nursery and school toothbrushing had driven five-year-old oral health improvement across all the full SIMD distribution (Macpherson et al., 2013a). The tension between delivering the toothbrushing component on a targeted vs universal basis was debated as an issue during the development of Childsmile (Shaw et al., 2009). This debate was resolved by ensuring that there were sufficient components of the Childsmile programme that were delivered universally to all children, while also targeting components based on those with greatest need (with need defined by socioeconomic circumstance) – thus following what Marmot coined as the proportionate universalism principle (Marmot and Bell, 2012).

The nursery and school toothbrushing component was considered a ‘core’ activity that could feasibly (and at a reasonable cost) be delivered to all children and also had the potential to benefit all children irrespective of deprivation. Additionally, from a practical point of view the toothbrushing programme had already begun in most health board areas, hence the decision to roll it out universally was taken.

Latterly, unpublished monitoring data from the Childsmile programme has begun to show variations in the delivery of supervised toothbrushing across the country – with it becoming apparent that, for example, toothbrushing was not always happening every day of the nursery/school week, or that children attending afternoons were not included if the toothbrushing session was in the morning. In addition, the thesis has shown that a greater number of years of participation in the toothbrushing component was strongly associated with a reduction in the odds of caries, but nevertheless there remains room to sustain and further improve or even extend participation in supervised toothbrushing.

This thesis has focused on dental caries by five-years-old as the primary outcome, however, epidemiological studies in Glasgow have shown significant caries levels and inequalities in oral health by three-years of age (McMahon et al., 2011). While other components of Childsmile focus on children in their early years, the toothbrushing component only commences when children start nursery, which for the majority of children, begins at three-years and continuing to five-years. In addition, the Scottish Government announced their aim to extend free nursery school placements which currently provides coverage for all three- and four-year-olds to include two-year-olds (whose parents qualify for benefits) by 2020 (Scottish Government, 2016d).

Therefore, this thesis points to a recommendation to optimise (and extend) the effective (and cost effective) nursery and school supervised toothbrushing. Optimisation should be in terms of working with nursery and school stakeholders to improve and maximise brushing coverage within establishments, and to extend this to even younger children from two-years of age. Also, there is potential to ensure that toothbrushing is continued amongst all nursery age children (two- to five-year olds) as nursery placements and hours extend over summer and other holiday periods. Qualitative process evaluation research is currently underway as part of another University of Glasgow PhD student (Jennifer Eaves).

5.8.2.4 Nursery and School Fluoride Varnish Application

The thesis has shown that limited benefits of the Nursery and School Fluoride Varnish Application component have been observed with regards to reducing the risk association with obvious caries experience. These results should be taken in conjunction with the preliminary findings from the randomised control trial of nursery fluoride varnish (Protecting Teeth @3 – PT@3), which shows no significant reduction in caries (Wright et al., 2018), alongside the recent comprehensive systematic review and meta-analysis which shows a modest and uncertain caries preventive effect of fluoride varnish in pre-schoolers (de Sousa et al., 2019)

Therefore, a review of the Childsmile nursery and school fluoride varnish programme is warranted.

5.8.2.5 Cross-cutting Recommendations

Each of the above sections on policy recommendations have proposed that the individual components of the programme are reviewed based on the findings of the thesis, other Childsmile evaluation work, and the up-to-date international evidence base. It is clear that each of these components should not be reviewed in isolation, but rather that the whole Childsmile programme is reviewed. Without pre-empting the detailed remit and scope of the review, there are some aspects of the programme delivery and effectiveness highlighted by this thesis that should be included.

The proposed Childsmile review should consider both the reach and implementation of the components including considerations of the Childsmile workforce and organisational structure in Health Boards. The review should also cover how best the components should be targeted and / or ensure universal coverage, with particular cognition of the need to use national SIMD. In addition, the review should explore whether or not other adaptions or whole-scale changes are needed.

Integral to a review of the implementation of Childsmile should be an appraisal of the resource allocation formula for the whole programme. This funding is largely devolved to health boards the from Scottish Government on a per capita basis, with limited consideration for socioeconomic deprivation, which has been shown to drive much of the oral health needs. More recently, the funding for the nursery and school fluoride varnish programme has changed to ensure that there are enhanced funds directed to boards with a greater share of the country's most socioeconomically deprived communities.

The relationship with the other initiatives that are related to child health ought to be included in the review. There have been other recent developments including the Scottish Government Challenge Fund which aims to improve the oral health of young children and families via third sector (voluntary and community) organisations (Scottish Government, 2019c). Twenty-two such organisations have been funded in the initial funding tranche, with proposed projects on child oral health and diet that are centred in organisations from deprived communities from across Scotland (Scottish Government, 2019b). Similarly, the ongoing evaluation of Health Visiting and the Early Years Pathways and any relevant recommendations that arise from this work should be considered.

Based on the findings of this thesis and its recommendations, the overarching review could guide the future direction of the Childsmile programme for the next decade.

Finally, it has been shown that it is viable to evaluate a complex public health intervention using routine multiple administrative linked datasets. This should be disseminated widely within the dental and public health research community in Scotland, UK, and internationally.

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Appendices

Appendix 1 – Privacy Advice Committee Approval Letter

Area 114E
Gyle Square
1 South Gyle Crescent
Edinburgh, EH12 9EB
Telephone 0131 275 6000
Fax 0131 275 7606
www.isdscotland.org

Dr D Conway
Senior Lecturer
University of glasgow Dental School
378 Sauchiehall Street
Glasgow
G2 3JZ

Date	15/01/2009
Your Ref	
Our Ref	TR/sh/52/08
Enquiries to	Susan Kerr, PAC Administrator
Direct Line	0131 275 6445
Email	susan.kerr@isd.csa.scot.nhs.uk

Dear Dr Conway

PAC Application Number 52 08
Evaluation and development of Childsmile- the national oral health demonstration programme for Scotland

The Privacy Advisory Committee has considered and approved your application for a data linkage in support of the above study.

Conditions applied: Prior to release, ISD wish to receive signed Confidentiality statements from local Caldicott Guardians in relation to the MIDAS related identifiable data.

Time period: As specified

Points highlighted: ISD would like to be informed of the outcomes of the University of Glasgow Ethics Committee approval process.

Any change to the terms of your application, including changes in data user(s), additional data fields or extension of the time period approved must be requested through Susan Kerr, PAC Administrator on 0131 275 6455 or susan.kerr@isd.csa.scot.nhs.uk.

In order to progress your request, please contact Janey Read, telephone number, 0131 275 6703 or email janey.read@isd.csa.scot.nhs.uk.

Kind regards.

Yours sincerely,

Dr Marion Bain
ISD Medical Director

c.c. Janey Read

Appendix 2 - Application to University of Glasgow Faculty of Medicine Research Ethics Committee for ethical approval for the evaluation of Childsmile (the national oral health demonstration programme).

Professor Lorna Macpherson
Professor of Dental Public Health
University of Glasgow, Faculty of Medicine
Glasgow Dental School
378 Sauchiehall Street
Glasgow G2 3JZ, UK
Tel. +44 (0)141 211 9760
E-mail: l.macpherson@dental.gla.ac.uk

University of Glasgow

Research Ethics Committee
Faculty of Medicine
University of Glasgow

24June 2009

Dear Dr Una Macleod,

Re. Application form for ethical approval for the evaluation of *Childsmile* (the national oral health demonstration programme).

The Community Oral Health Section of the Dental School at Glasgow - are leading on the evaluation of *Childsmile* the national oral health demonstration programme for NHS Dentistry in Scotland.

As per the email to all Faculty of Medicine staff (from Sarah Torbet - 10/06/08), we hereby submit an application form for ethical approval for the overarching evaluation approach which we are adopting.

Thus far we have been submitting ethics queries to NRES - who have decreed that the project is "NHS service development" and we have not required a full (NHS) ethics application. For specific 'component studies' (research projects) within the evaluation – where there are additional identifiable ethics issues – we have submitted specific project ethics applications. For example, we are currently completing the IRAS process in relation to a RCT on fluoride varnish which is being imbedded within *Childsmile*; and we have previously submitted an ethics application to December 2008 meeting of the University of Glasgow ethics committee on the *Childsmile*-based project investigating the role of the oral biofilm (a project being led by Dr Shauna Culshaw).

However, this application to the Faculty of Medicine Research Ethics Committee is in relation to the overarching evaluation process which we are working to.

To help clarify this application, here are two points of information:

1) While the project has been up and running since 2006 – and has thus far gone through NHS ethics procedures and been considered as a service development – this application for ethics approval is for the overall research evaluation and will enable us to go forward and pull the separate strands of the evaluation together within our department in the University.

2) Re. the application form. We have described the overarching evaluation and it does not always easily fit in with the application form questions. Nevertheless we have attempted to explain this process in detail within the form.

1

Enclosed is our application form for consideration for ethical approval by the committee. Please let me know if you require any further information at this stage.

A member of our research group would attend the committee if you felt this was necessary.

Many thanks.

Yours sincerely,

Lorna Macpherson

2

Appendix 3 – Extension to the University of Glasgow Faculty of Medicine Research Ethics Committee for ethical approval for the evaluation of Childsmile

University of Glasgow | College of Medical, Veterinary & Life Sciences

Dr Wendy Gnich
University of Glasgow Dental Hospital & School
378 Sauchiehall Street
Glasgow
G2 3JZ

15 May 2013

Dear Dr Gnich

MVLS College Ethics Committee

Project Title: **Evaluation and development of *Childsmile* – the national oral health demonstration programme for Scotland**

***Project No.* FM 04908**

The College Ethics Committee has reviewed the documents you submitted on 9 May 2013 in support of your request for a number of extensions to the above, overarching project.

I am pleased to inform you that the Committee has agreed to your requests. Specifically: (i) Since the national evaluation methods remain unchanged, project approval has been extended to 31 December 2016; (ii) As the initial approval was granted on the basis that the project would develop into a number of sub-components, approval is now granted for the two extensions for Mairi Young and Faith Hogins, entitled respectively, "Optimising the role of the DHSW in Childsmile Practice: A case study approach" and "A mixed methods approach to evaluating the Childsmile Practice referral pathway and exploring the Dental Health Support Worker role". The Committee will retain on file the documents relating to these sub-studies and their experimental protocols.

These extensions are granted subject to a number of pre-conditions:

- Mairi Young and Faith Hogins are permitted to interview parents of children. If they wish to interview or otherwise interact with children they would be required to undergo Disclosure/PVG checks with the results communicated to the Ethics Committee in advance.
- Clinical governance approval must be obtained from each NHS Board in which the fieldwork will be conducted.
- The research should be carried out only on the sites, and/or with the groups defined in the application.
- Any proposed changes in the protocol should be submitted for reassessment, except when it is necessary to change the protocol to eliminate hazard to the subjects or where the

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University of Glasgow | College of Medical, Veterinary & Life Sciences

change involves only the administrative aspects of the project. The Ethics Committee should be informed of any such changes.

- If the study does not start within three yeas of the date of this letter, the project should be resubmitted.
- You should submit a short end of study report to the Ethics Committee within 3 months of completion.

Yours sincerely

Professor William Martin
College Ethics Officer

Appendix 4 – Cover Letter to the NHS NSS ISD Caldicott Guardian was submitted detailing the amendments to the original Privacy Advice Committee Approval

University of Glasgow

CHILDSMILE

David Conway BDS, FDS, MPH, FFPH, PhD
Clinical Senior Lecturer in Dental Public Health
University of Glasgow Dental School
378 Sauchiehall Street
Glasgow G2 3JZ
Tel. +44 (0)141 211 9750
Email. david.conway@glasgow.ac.uk

Honorary Consultant in Public Health
Information Services Division
NHS National Services Scotland
Tel. 0131 275 6164
Email. david.conway@nhs.net

Dr. Janet Murray
Consultant in Public Health Medicine
ISD Caldicott Guardian
NHS National Services Scotland

1 March 2013

Dear Janet,

Re. Childsmile – data linkage and access approval for SHIP Pilot

Further to our discussion at the end of last year, I write to you as requested (rather than resubmit a PAC application) in relation to seeking approval for the data linkage and data access via SHIP for the purposes of the evaluation of Childsmile (the national child oral health improvement programme).

This letter also follows on previous PAC approvals for Childsmile evaluation work refs: PAC 20/11; PAC 66/10; and PAC 52/08.

The overarching aim of our evaluation of Childsmile is to assess the association between Childsmile interventions and outcomes. Therefore the focus of this phase of linkage analyses is to link within the ISD environment (and analyse via SHIP) data on Childsmile interventions with routine national health and service outcome datasets.

This evaluation is led by Prof Lorna Macpherson and myself, and our team is based in the Community Oral Health research team at the University of Glasgow Dental School.

The four data users for this linkage work are:
Dr. Alex McMahon, Reader of Epidemiology (Honorary Consultant in Epidemiology, ISD)
Dr. Andrea Sherriff, Senior Lecturer in Statistics;
Jamie Kidd, Childsmile Database Officer and PhD Student;
Faith Hodgins, PhD Student.

I can confirm that Alex, Jamie and Faith have all attended the 'ADLS Safe Researcher' information governance training course on 18th December 2012 and that Andrea will be attending the next available training course or completing the online shortly.

University of Glasgow

CHILDSMILE

Please find attached the detailed list of variables which we intend to link. They are listed in four broad sections:
Section 1 – ISD datasets
Section 2 – Childsmile (University of Glasgow) datasets
Section 3 – Childsmile – HIC Health Informatics Centre (University of Dundee) datasets

Data listed in Section 1 are already held in ISD, we have agreed and begun to receive data listed in Section 3 from HIC, and will do the same with Section 2 data shortly.

We have already held a joint meeting between ISD (dental and child health teams) and Community Oral Health group in Glasgow and plan to meet with the SHIP team shortly to discuss some of the logistics of the linkage.

I am happy to provide further information if required.

Yours sincerely,

David Conway

www.child-smile.org

NHS SCOTLAND

Appendix 5 – Public Benefit and Privacy Panel for Health and Social Care Approval Letter

Public Benefit and Privacy Panel for Health and Social Care
nss.PBPP@nhs.net
www.informationgovernance.scot.nhs.uk

NHS SCOTLAND

Mr Ahmed Mahmoud
University of Glasgow Dental School,
378 Sauchiehall Street,
Glasgow,
G2 3JZ

Date: 2nd November 2015
Your Ref:
Our Ref: 1516-0368 Mahmoud

Dear Mr Mahmoud,

Re: PBPP application 1516-0368 Mahmoud - Evaluation of Childsmile Outcomes

Thank you for your application for consideration by the Public Benefit and Privacy Panel for Health and Social Care. Your application has undergone proportionate governance review and has been approved, subject to the following conditions:

- Due to the volume of data and scope please add Data Protection Act 1998 – Schedule 3.8 to section 3.4.02 of the application form and re-submit the application as version 2.

This approval is given to process data as specified in the approved application form, and is limited to this. Approval is valid for the period specified in your application. You are required to notify the Panel Manager of any proposed change to any aspect of your proposal, including purpose or method of processing, data or data variables being processed, study cohorts, individuals accessing and processing data, timescales, technology/infrastructure, or any other relevant change.

I would take this opportunity to remind you of the declaration you have made in your application form committing you to undertakings in respect of information governance, confidentiality and data protection. In particular you should be aware that once personal data (irrespective of de-identification or other controls applied) has been extracted from NHSS Board(s) and transferred to you, that you will then become the Data Controller as defined by the Data Protection Act (1998).

Please note that summary information about your application and its approval, including the title and nature of your proposal, will be published on the panel website (www.informationgovernance.scot.nhs.uk).

I hope that your proposal progresses well,

Yours Sincerely

Nicola Starkey
(Interim) Panel Manager
NHS Scotland Public Benefit and Privacy Panel for Health and Social Care
Email: nss.PBPP@nhs.net

Appendix 6 – Letter from the West of Scotland Research Ethics Service

NHS
Greater Glasgow and Clyde

WoSRES
West of Scotland Research Ethics Service

Mr Ahmed Mahmoud
Senior Information Analyst
Resources Team
National Services Scotland

West of Scotland Research Ethics Service
Ground Floor – The Tennent Institute
Western Infirmary
38 Church Street
Glasgow G11 6NT

Date	13/03/15
Our Ref	WoS ASD 980
Direct line	0141 211 2126
Fax	0141 211 1847
E-mail	Judith.Godden@ggc.scot.nhs.uk

Dear Mr Mahmoud

Full title of project: *Evaluation of Childsmile Outcomes*

You have sought advice from the West of Scotland Research Ethics Service Office on the above project. This has been considered by the Scientific Officer and you are advised that based on the submitted documentation (email correspondence 3rd March 2015) it does not need NHS ethical review under the terms of the Governance Arrangements for Research Ethics Committees (A Harmonised Edition). This advice is based on the following.

- The project is research using only data obtained as part of usual care but note the requirement for PAC approval to permit sharing or publication of anonymised data obtained from patients under the care of NHS Scotland.

Note that this advice is issued on behalf of the West of Scotland Research Ethics Service and does not constitute a favourable opinion from a REC. It is intended to satisfy journal editors and conference organisers and others who may require evidence of consideration of the need for ethical review prior to publication or presentation of your results.

However, if you, your sponsor/funder or any NHS organisation feels that ethical review by a NHS REC is essential, please write setting out your reasons and we will be pleased to consider further.

Kind regards

Dr Judith Godden, WoSRES Scientific Officer/Manager

Appendix 7 – Ethical Approval from the University of Glasgow's College of Medical, Veterinary and Life Sciences Ethics Committee for Non-Clinical Research Involving Human Subjects

University of Glasgow

29/01/2016

MVLS College Ethics Committee

Project Title: **Childsmile: the national oral health programme for Scotland; Evaluation and development project: Phase II**
Project No: ***200150078***

Dear Dr Ross,

The College Ethics Committee has reviewed your application and has agreed that there is no objection on ethical grounds to the proposed study. It is happy therefore to approve the project.

- Project end date: March 2019
- The data should be held securely for a period of ten years after the completion of the research project, or for longer if specified by the research funder or sponsor, in accordance with the University's Code of Good Practice in Research: (http://www.gla.ac.uk/media/media_227599_en.pdf)
- The research shoud be carried out only on the sites, and/or with the groups defined in the application.
- Any proposed changes in the protocol should be submitted for reassessment, except when it is necessary to change the protocol to eliminate hazard to the subjects or where the change involves only the administrative aspects of the project. The Ethics Committee should be informed of any such changes.
- You should submit a short end of study report to the Ethics Committee within 3 months of completion.

Yours sincerely,

Jesse Dawson
MD, FRCP, BSc (hons), MBChB (hons)
Clinical Reader / Honorary Consultant

Chair MVLS Ethics Committee
College of Medicine, Veterinary & Life Sciences
Institute of Cardiovascular and Medical Sciences
Western Infirmary
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Tel – 0141 2116395 or page 4824

Appendix 8 – Medical Research Council Research Data and Confidentiality e-Learning Course Certificate for Jamie Kidd (May 2015)

MRC Medical Research Council

This is to certify that

Jamie Kidd

completed the following e-learning course assessment for Scotland with a score of
100%

Research Data and Confidentiality e-learning course

Covering:
- The concept of confidentiality and how to work within the law
- Principles 1, 2, 7, 8 and section 33 of the Data Protection Act
- Consent and the issues in accessing data for research without consent
- Appropriate disclosure and routes for access without consent
- Accessing data from ONS and the NHS
- Archiving and sharing research data

on Thu May 21 2015

Appendix 9 - Medical Research Council Research Data and Confidentiality e-Learning Course Certificate for Jamie Kidd (April 2018)

Medical Research Council
MRC

This is to certify that

Jamie Kidd

completed the following e-learning course assessment for Scotland with a score of
100%

Research Data and Confidentiality e-learning course

Covering:
- The concept of confidentiality and how to work within the law
- Principles 1, 2, 7, 8 and section 33 of the Data Protection Act
- Consent and the issues in accessing data for research without consent
- Appropriate disclosure and routes for access without consent
- Accessing data from ONS and the NHS
- Archiving and sharing research data

on Tue Apr 17 2018

Appendix 10 – List of Variables in the National Safe Haven for the Evaluation of Childsmile

Dataset/source Name	Variable	Time Period/Range	Processing only?
P1 Basic NDIP	CHI	2008/09–2014/15 inspection	Yes
	Forename	2008/09–2014/15 inspection	Yes
	Surname	2008/09–2014/15 inspection	Yes
	Postcode (child)	2008/09–2014/15 inspection	Yes
	DOB	2008/09–2014/15 inspection	No
	Gender	2008/09–2014/15 inspection	no
	NHS Board ID	2008/09–2014/15 inspection	no
	Postcode (school)	2008/09–2014/15 inspection	no
	Exam Date	2008/09–2014/15 inspection	no
	Year Group	2008/09–2014/15 inspection	no
	Exam Type	2008/09–2014/15 inspection	no
	No exam	2008/09–2014/15 inspection	no
	Repeat Exam	2008/09–2014/15 inspection	no
	A1 - Abscess or Infection	2008/09–2014/15 inspection	no
	A2 - Gross Caries	2008/09–2014/15 inspection	no
	A3 - Obviously carious Permanent Tooth	2008/09–2014/15 inspection	no
	B1 - Obviously carious Primary Tooth	2008/09–2014/15 inspection	no
	B2 - Possibly carious Permanent Tooth	2008/09–2014/15 inspection	no
	B3 - Missing Primary Molar	2008/09–2014/15 inspection	no
	B4 - Evidence of Restorations	2008/09–2014/15 inspection	no
	B5 - Poor OH	2008/09–2014/15 inspection	no
	C - No obvious caries experience	2008/09–2014/15 inspection	no
	Overall Category	2008/09–2014/15 inspection	no
P7 Basic NDIP	CHI	2008/09–2014/15 inspection	Yes
	Forename	2008/09–2014/15 inspection	Yes

	Surname	2008/09–2014/15 inspection	Yes
	Postcode (child)	2008/09–2014/15 inspection	Yes
	DOB	2008/09–2014/15 inspection	No
	Gender	2008/09–2014/15 inspection	no
	NHS Board ID	2008/09–2014/15 inspection	no
	Postcode (school)	2008/09–2014/15 inspection	no
	Exam Date	2008/09–2014/15 inspection	no
	Year	2008/09–2014/15 inspection	no
	Exam Type	2008/09–2014/15 inspection	no
	No exam	2008/09–2014/15 inspection	no
	Repeat exam	2008/09–2014/15 inspection	no
	A1 - Abscess or Infection	2008/09–2014/15 inspection	no
	A2 - Gross Caries	2008/09–2014/15 inspection	no
	B1 - Obviously carious Permanent Tooth	2008/09–2014/15 inspection	no
	B2 - Missing Permanent Tooth	2008/09–2014/15 inspection	no
	B3- Evidence of Restoration in Permanent Tooth	2008/09–2014/15 inspection	no
	B4- Erosion	2008/09–2014/15 inspection	no
	B5 - Poor OH	2008/09–2014/15 inspection	no
	B6 - Possible Orthodontic Treatment Needed	2008/09–2014/15 inspection	no
	B7 - Obviously carious Primary Tooth	2008/09–2014/15 inspection	no
	B8 - Untreated Trauma	2008/09–2014/15 inspection	no
	C1- No obvious caries experience	2008/09–2014/15 inspection	no
	C2 - Evidence of restored primary tooth	2008/09–2014/15 inspection	no
	Overall Category	2008/09–2014/15 inspection	no
Detailed P1	CHI Number	2008/09–2014/15 inspection	Yes
	Surname	2008/09–2014/15 inspection	Yes
	Forename	2008/09–2014/15 inspection	Yes

	Postcode (child)	2008/09–2014/15 inspection	Yes
	DOB	2008/09–2014/15 inspection	No
	Gender	2008/09–2014/15 inspection	No
	Postcode (school)	2008/09–2014/15 inspection	No
	ExamDate	2008/09–2014/15 inspection	No
	YearGroup	2008/09–2014/15 inspection	No
	RepeatExam	2008/09–2014/15 inspection	No
	Postcode	2008/09–2014/15 inspection	No
	MODid	2008/09–2014/15 inspection	No
	OHegiene	2008/09–2014/15 inspection	No
	Sepsis	2008/09–2014/15 inspection	No
Detailed P7	CHI Number	2008/09–2014/15 inspection	Yes
	Surname	2008/09–2014/15 inspection	Yes
	Forename	2008/09–2014/15 inspection	Yes
	Postcode (Child)	2008/09–2014/15 inspection	Yes
	DOB	2008/09–2014/15 inspection	No
	Gender	2008/09–2014/15 inspection	No
	Postcode (School)	2008/09–2014/15 inspection	No
	Exam Date	2008/09–2014/15 inspection	No
	Year Group	2008/09–2014/15 inspection	No
	Repeat Exam	2008/09–2014/15 inspection	No
	MODid	2008/09–2014/15 inspection	No
	OHegiene	2008/09–2014/15 inspection	No
	Sepsis	2008/09–2014/15 inspection	No
	Individual Tooth Level charting data not shown here		
SMR01	CHI	All children in base cohort	Yes
	Forename	All children in base cohort	Yes
	Surname	All children in base cohort	Yes

	Postcode (child)	All children in base cohort	Yes
	DOB	All children in base cohort	No
	Gender	All children in base cohort	No
	General Practitioner Practice Code	All children in base cohort	No
	Admission Date	All children in base cohort	No
	Speciality	All children in base cohort	
	Procedure Codes (OPCS4)	All children in base cohort	No
	Diagnosis codes (ICD10) – all six	All children in base cohort	No
	Supplementary Code	All children in base cohort	No
	Location/Hospital Code	All children in base cohort	No
	Location/Hospital Postcode	All children in base cohort	Yes
	Location/Hospital Health Board	All children in base cohort	No
	Ethnic group	All children in base cohort	No
SMR02	Mother's Ethnic Group	All children in base cohort	No
	Smoking History	All children in base cohort	No
	Smoker During Pregnancy	All children in base cohort	No
	Date of Delivery (Date of Birth)	All children in base cohort	No
	Baby 1 CHI	All children in base cohort	Yes
	Baby 1 Sex	All children in base cohort	No
	Baby 1 Birthweight	All children in base cohort	No
	Baby 2 CHI	All children in base cohort	Yes
	Baby 2 Sex	All children in base cohort	No
	Baby 2 Birthweight	All children in base cohort	No
	Baby 3 CHI	All children in base cohort	Yes
	Baby 3 Sex	All children in base cohort	No
	Baby 3 Birthweight	All children in base cohort	No
Scottish Birth Record (SBR)	Mothers Ethnic Group	All children in base cohort	No
	baby's Surname	All children in base cohort	Yes
	Baby's firstname	All children in base cohort	Yes

	Baby’s CHI	All children in base cohort	Yes
	Baby’s Postcode	All children in base cohort	Yes
	Baby’s Date of Birth	All children in base cohort	No
	Baby’s Sex	All children in base cohort	No
NRS Statutory Birth Record	Baby’s Forname	All children in base cohort	Yes
	Baby’s Surname	All children in base cohort	Yes
	Baby’s Postcode	All children in base cohort	Yes
	Baby’s DOB	All children in base cohort	No
	Baby’s Sex	All children in base cohort	No
	Parental occupational social class	All children in base cohort	No
	Mother's Country of Birth	All children in base cohort	No
	Mother's Employment Status	All children in base cohort	No
	Mother's Occupation	All children in base cohort	No
	Mother's Occupation Code	All children in base cohort	No
	Mother's Social Class/SEG	All children in base cohort	No
	Father's Occupation	All children in base cohort	No
	Father's Occupation Code	All children in base cohort	No
	Father's Country of Birth	All children in base cohort	No
	Father's Social Class/SEG	All children in base cohort	No
	Primary Household NSSEC Code	All children in base cohort	No
	Primary Household Occupation Code	All children in base cohort	No
	Primary Household Social Class/SEG	All children in base cohort	No
ScotXed School/Pupil Census	Forename	All children in base cohort	Yes
	Surname	All children in base cohort	Yes
	Postcode	All children in base cohort	Yes
	Scottish Candidate Number	All children in base cohort	Yes
	DOB	All children in base cohort	No
	Sex	All children in base cohort	No

	Ethnic Background	All children in base cohort	No
	Main Home Language	All children in base cohort	No
	Student Looked After	All children in base cohort	No
	Student need category	All children in base cohort	No
	Student need type	All children in base cohort	No
	Mode of attendance at special school (day/boarder)	All children in base cohort	No
	National Identity	All children in base cohort	No
	Student Mainstream Integration (half days spent in mainstream classes)	All children in base cohort	No
	Student Attendance at Special Schools/Units (half days spent in special schools)	All children in base cohort	No
	Nature of additional support provided	All children in base cohort	No
	Access to Physical /Curriculum/Communication Adaptation	All children in base cohort	No
	Asylum Status	All children in base cohort	No
	Free School Meal	All children in base cohort	No
ScotXed Looked After Children	Forename	All children in base cohort	Yes
	Surname	All children in base cohort	Yes
	Postcode	All children in base cohort	Yes
	Scottish Candidate Number	All children in base cohort	Yes
	DOB	All children in base cohort	No
	Gender	All children in base cohort	No
	Ethnic group	All children in base cohort	No
	Main Disability	All children in base cohort	No
	Episode start date (for each)	All children in base cohort	No
	Episode end date (for each)	All children in base cohort	No
	Has care plan	All children in base cohort	No
	Destination accommodation	All children in base cohort	No
	Pathway Plan	All children in base cohort	No
	Placement type	All children in base cohort	No

	Placement start date (for each)	All children in base cohort	No
	Placement end date (for each)	All children in base cohort	No
	Legal Reasons start date (for each)	All children in base cohort	No
	Legal Reasons end date (for each)	All children in base cohort	No
	Legal Reason	All children in base cohort	No
	Children ceasing to be looked after during reporting period	All children in base cohort	No
	Episode period (months)	All children in base cohort	No
ScotXed – Student Attendance and Absence	Forename	All children in base cohort	Yes
	Surname	All children in base cohort	Yes
	Postcode	All children in base cohort	Yes
	Scottish Candidate Number	All children in base cohort	Yes
	DOB	All children in base cohort	No
	Gender	All children in base cohort	No
	Attendance Codes	All children in base cohort	No
	Attendance values	All children in base cohort	No
Child Health Surveillance 27-30 Week Review	Forename	All children in base cohort	Yes
	Surname	All children in base cohort	Yes
	Postcode (child)	All children in base cohort	Yes
	DOB	All children in base cohort	No
	Date of assessment	All children in base cohort	No
	Gender	All children in base cohort	No
Child Health Surveillance 6-8 Week Review	Forename	1ST January 2003 onwards	Yes
	Surname	1ST January 2003 onwards	Yes
	Postcode (child)	1ST January 2003 onwards	Yes
	DOB	1ST January 2003 onwards	No
	Date of assessment	1ST January 2003 onwards	No

	Gender	1ST January 2003 onwards	No
	Feeding	1ST January 2003 onwards	No
	Exposure to passive smoking	1ST January 2003 onwards	No
	Health Plan Indicator (HPI)	1ST January 2003 onwards	No
	Historic Health Plan Indicator	1ST January 2003 onwards	No
	Childsmile referral	1ST January 2003 onwards	No
	PHN ID	1ST January 2003 onwards	No
	Health Board of Exam	1ST January 2003 onwards	No
	Practice Code	1ST January 2003 onwards	No
MIDAS (Treatments)	Forename	All children in base cohort	Yes
	Surname	All children in base cohort	Yes
	Postcode (child)	All children in base cohort	Yes
	DOB	All children in base cohort	No
	Gender	All children in base cohort	No
	Start date for treatment	All children in base cohort	No
	Stop date for treatment	All children in base cohort	No
	Fee code	All children in base cohort	No
	Description	All children in base cohort	No
	Number of claims	All children in base cohort	No
	List no.	All children in base cohort	No
	Location No.	All children in base cohort	No
	Postcode (dental practice)	All children in base cohort	No
	Amount claimed	All children in base cohort	No
	Special Needs Indicator	All children in base cohort	No
	Total Payment	All children in base cohort	No
	No. of Courses	All children in base cohort	No
	No. of Courses Paid	All children in base cohort	No
	No. of Treatments (Claimed)	All children in base cohort	No
	Total Payment	All children in base cohort	No
MIDAS (Registration)	Forename	All children in base cohort	Yes

	Surname	All children in base cohort	Yes
	Postcode (child)	All children in base cohort	Yes
	DOB	All children in base cohort	No
	Gender	All children in base cohort	No
	Date of registration	All children in base cohort	No
	Date of first attendance	All children in base cohort	No
	Date of last attendance	All children in base cohort	No
	List no.	All children in base cohort	No
	Location No.	All children in base cohort	No
	Postcode (Dental Practice)	All children in base cohort	No
	Reduced Registration Payment Indicator	All children in base cohort	No
	Latest Registration Indicator	All children in base cohort	No
	Registration Payment	All children in base cohort	No
	Reg Red Rate Start Date	All children in base cohort	No
	Registration Initial Date	All children in base cohort	No
	Registration Period Start Date	All children in base cohort	No
	Registration Period End Date	All children in base cohort	No
	Registration Payment End Date	All children in base cohort	No
	Registration Status Code	All children in base cohort	No
	Registration Status Description	All children in base cohort	No
	Special Needs Indicator	All children in base cohort	No
	Reported Flag	All children in base cohort	No
	Total Payment	All children in base cohort	No
Child Health Surveillance-child health school system Primary 1 Screening	Forename	All children in base cohort	Yes
	Surname	All children in base cohort	Yes
	Postcode (child)	All children in base cohort	Yes
	DOB	All children in base cohort	No

	Gender	All children in base cohort	No
	Height	All children in base cohort	No
	Weight	All children in base cohort	No
	BMI	All children in base cohort	No
	date_hw (Date height & weight measured)	All children in base cohort	No
	hb_exam	All children in base cohort	No
	School	All children in base cohort	No
	BMI SDS	All children in base cohort	No
	BMI centile	All children in base cohort	No
Childsmile Practice Dental Practice Interventions	Forename	All children in base cohort	Yes
	Surname	All children in base cohort	Yes
	Postcode (child)	All children in base cohort	Yes
	DOB	All children in base cohort	No
	gender	All children in base cohort	No
	Intervention Date	All children in base cohort	No
	Location Code	All children in base cohort	No
	Childsmile Practice Code	All children in base cohort	No
	Fee code	All children in base cohort	No
	Description	All children in base cohort	No
Health Visitor Caries Risk Assessment	Forename	All children in base cohort	Yes
	Surname	All children in base cohort	Yes
	Postcode (child)	All children in base cohort	Yes
	DOB	All children in base cohort	No
	gender	All children in base cohort	No
	Caries Risk Assessment Date	All children in base cohort	No
	Age of Mother	All children in base cohort	No
	Child lives in SIMD1	All children in base cohort	No

	Smoker in household	All children in base cohort	No
	Pain Relief	All children in base cohort	No
	Tooth Decay Risk	All children in base cohort	No
	Routine Care	All children in base cohort	No
	Accepted	All children in base cohort	No
	Declined	All children in base cohort	No
Invitation to Childsmile	Forename	All children in base cohort	Yes
	Surname	All children in base cohort	Yes
	Postcode (child)	All children in base cohort	Yes
	DOB	All children in base cohort	No
	gender	All children in base cohort	No
	DHSW Number	All children in base cohort	No
	Practice Number	All children in base cohort	No
	DCP Number	All children in base cohort	No
	Assessment Date	All children in base cohort	No
	Age of Mother	All children in base cohort	No
	Deprived Area	All children in base cohort	No
	Child dental pain	All children in base cohort	No
	Smoker in household	All children in base cohort	No
	Pain Relief	All children in base cohort	No
	Tooth Decay Risk	All children in base cohort	No
	Routine Care	All children in base cohort	No
	Accepted	All children in base cohort	No
	Declined	All children in base cohort	No
	Dental Services ID	All children in base cohort	No
	Appointment Date	All children in base cohort	No
Dental Health Support Worker First Visit	Forename	All children in base cohort	Yes
	Surname	All children in base cohort	Yes
	Postcode (child)	All children in base cohort	Yes

	DOB	All children in base cohort	No
	gender	All children in base cohort	No
	DHSW ID	All children in base cohort	No
	Contact Date	All children in base cohort	No
	Programme explained	All children in base cohort	No
	Existing dentist	All children in base cohort	No
	Childsmile Practice	All children in base cohort	No
	Dental Practice ID	All children in base cohort	No
	Appointment Date	All children in base cohort	No
	Own Dentist	All children in base cohort	No
	Not chosen	All children in base cohort	No
	Do not want	All children in base cohort	No
Record of Child/Parent Contact	Forename	All children in base cohort	Yes
	Surname	All children in base cohort	Yes
	Postcode (child)	All children in base cohort	Yes
	DOB	All children in base cohort	No
	gender	All children in base cohort	No
	Date of planned visit	All children in base cohort	No
	DHSW ID	All children in base cohort	No
	Attendance	All children in base cohort	No
	Dietary Advice	All children in base cohort	No
	Toothbrushing Advice	All children in base cohort	No
	Dental Pack Issued	All children in base cohort	No
	Dental Services Date	All children in base cohort	No
	Home Visit Date	All children in base cohort	No
Dental Health Support Worker Courtesy Visit	Forename	All children in base cohort	Yes
	Surname	All children in base cohort	Yes
	Postcode (child)	All children in base cohort	Yes
	DOB	All children in base cohort	No

	gender	All children in base cohort	No
	DHSW ID	All children in base cohort	No
	Practice Date	All children in base cohort	No
	Courtesy Visit Date	All children in base cohort	No
	Second Appointment	All children in base cohort	No
	Date of Next Appointment	All children in base cohort	No
DHSW Childsmile Practice Form	Forename	All children in base cohort	Yes
	Surname	All children in base cohort	Yes
	Postcode (child)	All children in base cohort	Yes
	DOB	All children in base cohort	No
	gender	All children in base cohort	No
	DHSW ID	All children in base cohort	No
	Date of Visit	All children in base cohort	No
	Type of contact	All children in base cohort	No
	Result	All children in base cohort	No
	Reason for declining	All children in base cohort	No
	Dietary	All children in base cohort	No
	Toothbrushing	All children in base cohort	No
	Dental Pack	All children in base cohort	No
	Dental Services	All children in base cohort	No
	Dental Services Code	All children in base cohort	No
	Dental Date	All children in base cohort	No
	Home Support	All children in base cohort	No
	Home Date	All children in base cohort	No
	Re-contact family (FTA)	All children in base cohort	No
	Dental Pack Delivered	All children in base cohort	No
	Refused Refer to HV	All children in base cohort	No
	Re-Schedule	All children in base cohort	No
	Refer to HV	All children in base cohort	No

	No further action	All children in base cohort	No
Toothbrushing Consent	CHI	All children in base cohort	Yes
	Forename	All children in base cohort	Yes
	Surname	All children in base cohort	Yes
	Postcode (child)	All children in base cohort	Yes
	gender	All children in base cohort	No
	DOB	All children in base cohort	No
	Intervention ID	All children in base cohort	No
	Consent id	All children in base cohort	No
	Consent date	All children in base cohort	No
	Consent type	All children in base cohort	No
	Consent version	All children in base cohort	No
	Tb consent result	All children in base cohort	No
	Find dentist	All children in base cohort	No
	Contact for update	All children in base cohort	No
	Parental responsibility	All children in base cohort	No
	Health information	All children in base cohort	No
	optout	All children in base cohort	No
	Date optout	All children in base cohort	No
Fluoride Varnish Consent	CHI	All children in base cohort	Yes
	forenames	All children in base cohort	Yes
	surname	All children in base cohort	Yes
	postcode	All children in base cohort	Yes
	date_of_birth	All children in base cohort	No
	sex	All children in base cohort	No
	optout	All children in base cohort	No
	date_optout	All children in base cohort	No
	consent_id	All children in base cohort	No
	consent_dt	All children in base cohort	No
	consent_version	All children in base cohort	No

	fv_consent_result	All children in base cohort	No
	find_dentist	All children in base cohort	No
	contact_for_update	All children in base cohort	No
	parental_responsibility	All children in base cohort	No
	health_information	All children in base cohort	No
	guardian_present	All children in base cohort	No
	allergy	All children in base cohort	No
	allergic_to	All children in base cohort	No
	hospitalised	All children in base cohort	No
	hospitalised_date	All children in base cohort	No
	validated_by	All children in base cohort	No
	validated_by_postcode	All children in base cohort	No
	dt_validated	All children in base cohort	No
	validation_source	All children in base cohort	No
Fluoride Varnish Visit	CHI	All children in base cohort	Yes
	Forename	All children in base cohort	Yes
	Surname	All children in base cohort	Yes
	Postcode (child)	All children in base cohort	Yes
	DOB	All children in base cohort	No
	gender	All children in base cohort	No
	Intervention ID	All children in base cohort	No
	Consen id	All children in base cohort	No
	Visit dt	All children in base cohort	No
	Varnish	All children in base cohort	No
	Varnish applied by	All children in base cohort	No
	Varnish applied by postcode	All children in base cohort	No
	Varnish type	All children in base cohort	No
	Batch	All children in base cohort	No
	Batch expiry	All children in base cohort	No
	quadrant_5	All children in base cohort	No

	quadrant_6	All children in base cohort	No
	quadrant_7	All children in base cohort	No
	quadrant_8	All children in base cohort	No
	Referral caries	All children in base cohort	No
	Referral abscess	All children in base cohort	No
	Referral other	All children in base cohort	No
	Reason varnish not applied	All children in base cohort	No
	Reason referral letter	All children in base cohort	No
	Visit result	All children in base cohort	No
	optout	All children in base cohort	No
	Date optout	All children in base cohort	No
Monitoring Visit	school_id	All children in base cohort	No
	School name	All children in base cohort	No
	School postcode	All children in base cohort	No
	Health board id	All children in base cohort	No
	School nursery flag	All children in base cohort	No
	chp	All children in base cohort	No
	Contact id	All children in base cohort	No
	Visit dt	All children in base cohort	No
	incomplete	All children in base cohort	No
	Class monitored	All children in base cohort	No
	Staff member	All children in base cohort	No
	Number of Children on roll	All children in base cohort	No
	Number of children attending on day of visit	All children in base cohort	No
	Number of children brushing on day of visit	All children in base cohort	No
	Brushing location	All children in base cohort	No
	Paste dispensed	All children in base cohort	No
	Rinsed by	All children in base cohort	No
	Spit location	All children in base cohort	No

	supervised	All children in base cohort	No
	Wall chart	All children in base cohort	No
	Standards visible	All children in base cohort	No
	Storage systems clean	All children in base cohort	No
	Storage system	All children in base cohort	No
	Brush replaced	All children in base cohort	No
	Brush condition	All children in base cohort	No
	Brush days	All children in base cohort	No
	Improvement organisation	All children in base cohort	No
	Improvement practice	All children in base cohort	No
	Improvement infection	All children in base cohort	No
	Feedback provided	All children in base cohort	No
	Completed by	All children in base cohort	No
	Completed by postcode	All children in base cohort	No
Toothbrush Packs Visit	School id	All children in base cohort	No
	School name	All children in base cohort	No
	School postcode	All children in base cohort	No
	Health board id	All children in base cohort	No
	School nursery flag	All children in base cohort	No
	chp	All children in base cohort	No
	Contact id	All children in base cohort	No
	Visit dt	All children in base cohort	No
	Num packs n	All children in base cohort	No
	Num packs p1	All children in base cohort	No
	Num packs p2	All children in base cohort	No
	Num packs p3	All children in base cohort	No
	Num packs p4	All children in base cohort	No
	Num packs p5	All children in base cohort	No
	Num packs p6	All children in base cohort	No
	Num packs_p7	All children in base cohort	No

	Num packs sped	All children in base cohort	No
	Completed by	All children in base cohort	No
	Completed by postcode	All children in base cohort	No
Establishment Contact	School id	All children in base cohort	No
	School name	All children in base cohort	No
	School postcode	All children in base cohort	No
	Health board id	All children in base cohort	No
	School nursery flag	All children in base cohort	No
	chp	All children in base cohort	No
	Contact id	All children in base cohort	No
	Contact type	All children in base cohort	No
	Dt start	All children in base cohort	No
	Dt end	All children in base cohort	No
	vehicles	All children in base cohort	No
	staff_member_1	All children in base cohort	No
	staff_member_1_postcode	All children in base cohort	No
	staff_member_1_duration	All children in base cohort	No
	staff_member_2	All children in base cohort	No
	staff_member_2_postcode	All children in base cohort	No
	staff_member_2_duration	All children in base cohort	No
	staff_member_3	All children in base cohort	No
	staff_member_3_postcode	All children in base cohort	No
	staff_member_3_duration	All children in base cohort	No
	staff_member_4	All children in base cohort	No
	staff_member_4_postcode	All children in base cohort	No
	staff_member_4_duration	All children in base cohort	No
	staff_member_5	All children in base cohort	No
	staff_member_5_postcode	All children in base cohort	No
	staff_member_5_duration	All children in base cohort	No
	staff_member_6	All children in base cohort	No

	staff_member_6_postcode	All children in base cohort	No
	staff_member_6_duration	All children in base cohort	No
	staff_member_7	All children in base cohort	No
	staff_member_7_postcode	All children in base cohort	No
	staff_member_7_duration	All children in base cohort	No
	staff_member_8	All children in base cohort	No
	staff_member_8_postcode	All children in base cohort	No
	staff_member_8_duration	All children in base cohort	No
	staff_member_9	All children in base cohort	No
	staff_member_9_postcode	All children in base cohort	No
	staff_member_9_duration	All children in base cohort	No
Class List Addition	CHI	All children in base cohort	Yes
	Forename	All children in base cohort	Yes
	Surname	All children in base cohort	Yes
	Postcode (child)	All children in base cohort	Yes
	DOB	All children in base cohort	No
	gender	All children in base cohort	No
	Class list id	All children in base cohort	No
	School id	All children in base cohort	No
	School name	All children in base cohort	No
	School postcode	All children in base cohort	No
	health_board_id	All children in base cohort	No
	school_nursery_flag	All children in base cohort	No
	chp	All children in base cohort	No
	child_id	All children in base cohort	No
	class_type	All children in base cohort	No
	date	All children in base cohort	No
Class List Removal	CHI	All children in base cohort	Yes
	Forename	All children in base cohort	Yes
	Surname	All children in base cohort	Yes

	Postcode (child)	All children in base cohort	Yes
	DOB	All children in base cohort	No
	gender	All children in base cohort	No
	class_list_id	All children in base cohort	No
	school_id	All children in base cohort	No
	School name	All children in base cohort	No
	School postcode	All children in base cohort	No
	health_board_id	All children in base cohort	No
	school_nursery_flag	All children in base cohort	No
	chp	All children in base cohort	No
	child_id	All children in base cohort	No
Practice Diary Event	CHI	All children in base cohort	Yes
	Forename	All children in base cohort	Yes
	Surname	All children in base cohort	Yes
	Postcode (child)	All children in base cohort	Yes
	DOB	All children in base cohort	No
	gender	All children in base cohort	No
	health_board_id	All children in base cohort	No
	dental_worker	All children in base cohort	No
	dental_worker_postcode	All children in base cohort	No
	referral_by_at	All children in base cohort	No
	referral_other	All children in base cohort	No
	health_visitor	All children in base cohort	No
	date_of_referral	All children in base cohort	No
	health_visitor_id	All children in base cohort	No
	health_visitor_base	All children in base cohort	No
	statement_read	All children in base cohort	No
	contact_type	All children in base cohort	No
	dt_start	All children in base cohort	No
	dt_end	All children in base cohort	No

Practice Intervention	CHI	All children in base cohort	Yes
	Forename	All children in base cohort	Yes
	Surname	All children in base cohort	Yes
	Postcode (child)	All children in base cohort	Yes
	DOB	All children in base cohort	No
	gender	All children in base cohort	No
	health_board_id	All children in base cohort	No
	dental_worker	All children in base cohort	No
	dental_worker_postcode	All children in base cohort	No
	referral_by_at	All children in base cohort	No
	referral_other	All children in base cohort	No
	health_visitor	All children in base cohort	No
	date_of_referral	All children in base cohort	No
	health_visitor_id	All children in base cohort	No
	health_visitor_base	All children in base cohort	No
	statement_read	All children in base cohort	No
	dt_intervention	All children in base cohort	No
	type	All children in base cohort	No
	result	All children in base cohort	No
	declined_reason	All children in base cohort	No
	dietary_advice	All children in base cohort	No
	toothbrushing_advice	All children in base cohort	No
	dental_pack	All children in base cohort	No
	outcome_home_support	All children in base cohort	No
	outcome_dental_services	All children in base cohort	No
	dental_practice_code	All children in base cohort	No
	action_pack_delivered	All children in base cohort	No
	action_recontact	All children in base cohort	No
	action_refer	All children in base cohort	No
	action_reschedule	All children in base cohort	No

	action_refused	All children in base cohort	No
	action_noaction	All children in base cohort	No
	family_nocontact	All children in base cohort	No
	additionalstudy	All children in base cohort	No
	dt_outcome_home_support	All children in base cohort	No
	dt_outcome_referral	All children in base cohort	No
	signposting	All children in base cohort	No
	signposting_list	All children in base cohort	No
	signposting_notes	All children in base cohort	No
	chatterbox_intervention	All children in base cohort	No
	additional_study	All children in base cohort	No
SIMD2009 (VERSION 2)	Postcode	All children in base cohort	Yes
	Datazone	All children in base cohort	No
	SIMD Quintile (National)	All children in base cohort	No
	SIMD Decile (National)	All children in base cohort	No
	SIMD Quintile (Local)	All children in base cohort	No
	SIMD Decile (Local)	All children in base cohort	No
	Overall SIMD Rank	All children in base cohort	No
	LA_Name	All children in base cohort	No
	CHP_Name	All children in base cohort	No
	HB_Name	All children in base cohort	No
	UR6_Desc	All children in base cohort	No
	Income Domain Rank	All children in base cohort	No
	Employment Domain Rank	All children in base cohort	No
	Health Domain Rank	All children in base cohort	No
	Education Domain Rank	All children in base cohort	No
	Housing Domain Rank	All children in base cohort	No
	Access Domain Rank	All children in base cohort	No
	Crime Domain rank	All children in base cohort	No