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Improving the Quality of Caries Prevention

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Submitted in the fulfilment of the requirements for the
Degree of MSc by Research

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Abstract

Introduction

Dental caries has long been a significant child health issue in Scotland. Significant advances have been made in recent years in tackling this issue. However, as dental caries has become less endemic to the population as a whole, it is now increasingly concentrated within a high risk segment. There are a number of effective preventive interventions that can be targeted to those at higher risk. Clinical guidelines recommend the practice of assessing an individual's caries risk and implementing an appropriate prevention plan. Unfortunately, the translation of clinical guidelines to routine clinical practice is inconsistent throughout healthcare; including dentistry. This inconsistency results in patient receiving suboptimal care and in some cases irreversible harm. This inconsistency of practice is increasingly being identified as an unnecessary cost to the healthcare services, potentially causing patients to receiving suboptimal care and potentially irreversible harm. Therefore, efforts are being targeted at interventions that improve the consistent translation of best evidence to routine practice.

Aims and Objectives

Primary Aim - To improve the documentation of a caries risk assessment (CRA) for all patients attending the department of paediatric dentistry by application of a systems based approach to quality improvement methods.

Secondary Aim - To investigate the impact of these quality improvement efforts on the subsequent delivery of preventive care.

Materials and Methods

This work was carried out with the department of Paediatric dentistry at Glasgow Dental Hospital and School over a 25 month period. Improvement of CRA was driven by the Plan-Do-Study-Act improvement method and was termed the Caries Assessment Risk Evaluation (CARE) project. This was monitored and guided by the use of a run chart, with data provided by random sampling of 5 case notes on a weekly basis.

The impact that this improvement was having on preventive care delivery was monitored during the project by undertaking two retrospective surveys. These compared preventive care received by patients who did have a completed CARE tool with those who did not. At the end of the study a retrospective survey was carried out comparing the preventive care received by a random sample of patients prior to any improvement work (2007) with a random sample once the improvement work was well established (2010).

Results

Over the 25 months of the study there was a significant variability in the monitoring of CRA completion. In the first months of the project performance shifted to around 40%, whilst by the end of this project a shift in performance to around 80% was detected. A notable difference in the consistency of performance of completion of a CRA by the different staff groups ($p < 0.001$) and clinics ($p = 0.04$) within the department was detected. A clear impact on performance was seen when systems of working were disrupted by environmental constraints.

The two surveys of preventive care received by the patients who did have a completed CARE tool in comparison to those who did not, consistently found that those patients with a completed CARE tool had more documented preventive care delivered. The 2007 versus 2010 audit found that CRA ($p < 0.001$), radiographs ($p = 0.004$), oral hygiene instruction ($p < 0.001$), fluoride varnish ($p < 0.001$), toothpaste strength ($p < 0.001$) and diet advice ($p < 0.001$) had all significantly improved following the implementation of the project.

Conclusions

This study found that improvement in oral health care is possible by applying a systems based approach to ensure translation of best evidence into routine practice. The greatest consistency in improvement was achieved when new processes could be integrated that complemented current working practice. The challenge remains to develop such complementary systems that are suitable for the wide variety of clinical situations that present in daily practice. The evidence from this study supports the hypothesis that improving CRA compliance leads to an improvement in documented delivery of other preventive interventions.

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List of Abbreviations

AGREE	Appraisal of Guidelines- Research and Evaluation for Europe
BSPD	British Society of Paediatric Dentistry
CARE	Caries Assessment Risk Evaluation
CDS	Community Dental Service
CI	Confidence Interval
CQM	Continuous Quality Management
CRA	Caries Risk Assessment
dmft	Decayed Missing or Filled Teeth (deciduous)
DMFT	Decayed Missing or Filled Teeth (permanent)
EAPD	European Academy of Paediatric Dentistry
F- Varnish	Fluoride Varnish
F/S on FPMs	Fissure sealants on first permanent molars
GA	General Anaesthesia
GDHS	Glasgow Dental Hospital and School
GDP	General Dental Practitioner
GDS	General Dental Service
HDS	Hospital Dental Service
HDU	High Dependency Unit
HEAT	Health improvement, Efficiency, Access and Treatment
ICU	Intensive Care Unit
IMRaD	Introduction, Methods, Results and Discussion
ISO	International Organisation for Standardisation
NDIP	National Dental Inspection Programme
NHS	National Health Service
NRES	National Research Ethics Service
OHRP	United States Office for Human Research Protections
PCPCS	Primary Care Provider Communication Sheet
PDSA	Plan-Do-Study-Act
QI	Quality Improvement
RCPSG	Royal College of Physicians and Surgeons Glasgow
s.d.	Standard Deviation
SDCEP	Scottish Dental Clinical Effectiveness Programme
SHO	Senior House Officer
SIGN	Scottish Intercollegiate Guidelines Network
SIMD	Scottish Index of Multiple Deprivation
SPC	Statistical Process Control
SpR	Specialist Registrar
SPSP	Scottish Patient Safety Programme
SQUIRE	Standard for Quality Improvement Reporting Excellence
TBI	Toothbrushing Instruction
TPS	Toothpaste Strength advice
TQM	Total Quality Management
UK	United Kingdom
USA	United States of America
VSS	Vulnerable System Syndrome
WHO	World Health Organisation

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Author's Declaration

I declare that this thesis is the result of my own work and has not been submitted for any other degree at the University of Glasgow or any other institution.

Chapter 1 – Introduction

1.1 Literature Search Strategy

In preparation for this thesis a search of the literature was undertaken as detailed in appendix 1.

1.2 Background to Dental Care for Children in Scotland

The poor dental health of children in the United Kingdom (UK), particularly in Scotland, is a long standing issue. William MacPherson Fisher and George Cunningham identified the appalling state of children's teeth as an issue in Victorian Britain. William MacPherson Fisher was an early advocate for the treatment of children's teeth, with his 1885 address to the British Dental Society entitled "Compulsory Attention to the Teeth of School Children" ("Obituary - William MacPherson Fisher, LDSEng," 1938). The following year George Cunningham addressed the British Dental Society calling on Government to provide funding for dental care for school children (Zangwill, 2001). However, dental treatment for children remained controversial in the first half of the 20th century, with signs stating "children not accepted" being freely distributed to UK dentists as late as the 1930s (Burt, 1978). Over the course of the twentieth century, advances such as the introduction of fluoride toothpastes and the National Health Service (NHS), led to significant improvements in oral health in the UK (Jones et al., 2005). Unfortunately, poor dental health continues to remain an important issue, especially amongst young children (Curzon, 2010).

1.2.1 The State of Children's Teeth in Scotland

In Scotland the National Dental Inspection Programme (NDIP), is carried out annually across the country. Calibrated examiners are sent into schools, and the programme switches on an annual basis from assessing Primary 1's (5-year olds) and Primary 7's (12-year olds). The 2010 inspection found that almost half of Scottish 5-year olds experience significant levels of dental decay (Macpherson et al., 2010a). Marked socioeconomic inequalities underlie this figure, with those from the most deprived communities experiencing more disease. Registration with a dental practitioner of very young children (0-2 years), who can benefit the most from preventive care, remains very low. By the end of the first decade

of the 21st century, dental registration amongst children under the age of 3 years had only reached 40% across Scotland (NHS Information Services Division, 2009). A recent survey of the dental health of 3 year old children in Glasgow highlighted that 25% had obvious evidence of dental caries (McMahon et al., 2010). Registration levels in the 3-5 years age group do increase to around 80%, however, for many the disease will be established by this age.

1.2.2 Dental Care in Scotland

The vast majority of dental care for children is provided by independent high street dentists, or the general dental services (GDS); which are general dental practitioners (GDPs) who work under contract to the NHS. As of March 2011 the total spend by the NHS providing children's dental care within the GDS was over £64 million (NHS Information Services Division, 2011). However, significant variation exists in terms of how much is spent annually per child head of population in the different health boards of Scotland, ranging from £72 per child in Greater Glasgow and Clyde, to £31 in the Western Isles.

How GDPs are paid by the NHS to provide dental care for children under a mixture of fee for item of treatment and capitation payment. Capitation means that the practitioner is paid a set fee for every child they are responsible for providing care for. The GDP is expected to provide:

“...the care and treatment necessary to secure and maintain oral health including all necessary preventive measures.” (The Scottish Dental Practice Board, 2008)

In 2010 the NHS paid GDPs approximately £37.5 million in capitation payments and £10 million in treatment fees (excluding those related to orthodontics) (NHS Information Services Division, 2011; Scottish Dental Practice Board, 2011). A review of the provision of dental care to those children registered under the capitation payment system has highlighted that extremely limited preventive activity was being undertaken by dentists (Scottish Dental Practice Board, 2006). This agrees with Threlfall *et al.*'s finding that most GDPs deliver preventive advice in an unstructured fashion; rapidly becoming disillusioned with patient's they perceive to be unresponsive to preventive messages (Threlfall et al., 2007). In further support of this, Tickle *et al.* reported that preventive interventions in

general dental practice were primarily delivered reactively, in response to the discovery of disease; rather than prescribed in a proactive fashion (Tickle et al., 2003). In Scotland, the Childsmile programme is attempting to address this issue, by developing a GDS system that is proactive at delivering prevention (See 1.2.5.2 Childsmile, Page 28).

Alongside the paediatric dental care provided by the GDS, there are paediatric dental services provided within the community dental service (CDS) and the hospital dental service (HDS). Dentists working within the CDS and HDS are salaried employees of the NHS, and so have no direct economic incentives relating to the numbers of patients seen or types of treatments provided. Historically the CDS and HDS have existed to act as supporting services for the GDS; caring for patients unable or unsuitable to be seen in GDS. For example; providing services in areas where no GDS coverage exists; care for special needs patients; care for complex dental conditions; or providing services that would not be practical within the GDS, i.e. general anaesthesia. There have been concerns about the relative productivity of salaried dentists working in the CDS or HDS, as in purely numerical terms they will see significantly fewer patients than a dentist working in the GDS (Taylor et al., 2006). However, given that the CDS and HDS primarily serve a cohort of patients deemed to be unsuitable for treatment in GDS; drawing direct numerical comparisons like this is arguably flawed.

1.2.3 Clinical Guidelines

In the United States Institute of Medicine report on the topic, clinical guidelines were defined as the following:

“systematically developed statements to assist practitioner and patient decisions about appropriate health care for specific clinical circumstances” (Field, 1990)

This definition was used as basis for the Scottish Intercollegiate Guidelines Network (SIGN), which was formed in 1993 by the Academy of Royal Colleges and their Faculties in Scotland. Its aim was to produce evidence based guidelines for the use of healthcare practitioners in Scotland. Initially these guidelines were developed based on locally agreed criteria (Petrie et al., 1995) and since 2003,

have been based on the Appraisal of Guidelines- Research and Evaluation for Europe (AGREE) appraisal instrument, which in 2010 was superseded by AGREE II (Brouwers et al., 2010). The objective of SIGN guidelines is to aid practitioners in accessing the best evidence on a topic, by systematically collecting and appraising the available evidence. The guidelines are not intended to be prescriptive, rather to aid the diffusion of evidence based best practice and reduce harmful variations in patient care (SIGN, 2008).

In relation to oral health, three SIGN guidelines documents have been produced. First in March 2000, SIGN 43 - "Management of unerupted and impacted third molar teeth"; followed in December 2000 by, SIGN 47 - "Preventing dental caries in children at high caries risk"; and finally in November 2005, SIGN 83 - "Prevention and management of dental caries in the pre-school child". In relation to this thesis, SIGN 47 and 83 are important documents, as they highlighted the importance of caries risk assessment as a prerequisite in developing tailored preventive interventions to the dental profession in Scotland (SIGN, 2005, 2000a, 2000b).

The Scottish Dental Clinical Effectiveness Programme (SDCEP) was established in 2004 as an initiative by the National Dental Advisory Committee. The aim of which was to produce guidance that dental practitioners could easily interpret and implement. In April 2010 SDCEP published its guidance entitled - Prevention and Management of Dental Caries in Children (Evans et al., 2010). This holistic documented covered a range of topics relating to children's dentistry, including assessment, behaviour management, caries prevention, caries management and other advanced techniques. This documented further reinforced SIGN 47 and 83, in placing further emphasis on the importance of caries risk assessment and tailored prevention plans.

This guideline movement was intended to help address some of the difficulties in translating evidence into practice. Though there is some resistance to this as it is seen by some to infringe on the "art of medicine" or reduce medicine to "cookbook medicine" (Berwick, 2005; Grahame-Smith, 1995; Sackett et al., 1996; Straus and McAlister, 2000). However, it could also be argued that the rapid increase in knowledge relating to disease biology and effective therapies, requires a change to the perceived role of the medical practitioner. In that

their role now is to be able to decide upon and tailor the correct pre-existing disease management “recipe” to the particular patient, rather than continually developing a new “recipe” from scratch (Kennedy and Pronovost, 2006; Tomson, 2009).

1.2.4 Health Promotion

The SIGN 83 document defined health promotion as the following:

“**Health promotion** supports individuals in translating their health knowledge into positive behaviour and lifestyles. Health promotion activities should be directed at a wide variety of areas likely to impact on health, e.g. social, economic and structural environments as well as the policies of public and local institutions. The rationale is to increase the communities day-to-day capacity to follow a healthy lifestyle.” (SIGN, 2005)

This conforms to the international definition of health promotion as set forward in the World Health Organisation’s (WHO) Ottawa charter:

“The process of enabling individuals and communities to increase control over the determinants of health and thereby improve their health. Health promotion represents a mediating strategy between people and their environment, combining personal choice and social responsibility for health to create a healthier future.” (World Health Organization, 1986)

1.2.4.1 Approaches to Health Promotion

Rose in 1985 proposed two, now widely accepted, definitions of approaches to prevention of disease. The first being the individual (targeted) approach, whilst the second is the population (universal) approach (Rose, 1985).

1.2.4.2 Targeted Approach

In the targeted approach, individuals are screened for the presence of certain risk factors and those identified as being at high risk of developing a disease are started on an appropriate preventive regime. This targeted approach has the advantage of tailoring preventive interventions to the individual patient and hopefully improved patient compliance with treatment. Potentially costly interventions can also be directed towards those patients who will most likely

benefit from them. This approach is therefore very popular with health professionals; as it fits well with a clinical approach to prevention.

However, there are limitations to the targeted approach. Firstly, the screening for high-risk individuals may be costly and as these risk factors may vary over a lifetime, the screenings will need to be constantly repeated. All screening programmes face the difficulty of uptake. Screening the sections of society most likely to be at risk are the most difficult, as they tend to be those least likely to attend for screening. The predictive power of most risk factors tends to be fairly weak and often the best predictor of future disease is the presence of current disease. Yet, using the presence of current disease fundamentally defeats the purpose of a preventive intervention.

Another weakness of the targeted approach occurs if the size of the low risk population is significantly larger than the high risk population; because of the larger size of population, it will be within the low risk population where the majority of new disease arises. A final weakness with the targeted approach is that the preventive strategy often requires the individual to behave in a way that is markedly different from their peers. Attempting to behave in a way that markedly differs from the perceived social norms can be extremely challenging for an individual to achieve (Watt, 2005).

1.2.4.3 Universal Approach

The universal approach to prevention is to attempt to lower the mean level of risk for development of a disease across the population as a whole. This can be in the form of mass environmental control, for example vaccination or water fluoridation, or attempting to alter society's norms of behaviour, for example smoking. The advantage of this approach is when multiplied across the population, a relatively small preventive effect can actually prevent a large number of new disease cases. A prime example of this being water fluoridation, estimated by the York review to reduce caries prevalence by 15% (McDonagh et al., 2000).

However, the universal approach also has several drawbacks. It may offer only a small reduction in risk to the individual, as most individuals may be unlikely to

develop the disease, at least in the short to medium term. This creates what has been termed the ‘prevention paradox’ – in that a preventive measure which may be of benefit across the population as a whole; may offer little benefit to the individual and may actually cause them inconvenience in terms of changes to lifestyle and behaviour (Rose, 1981). Motivation for medical professionals to engage in such preventive approaches may be minimal, as uptake by patients of the intervention may be extremely low and a successful preventive intervention is only marked by a non-event (the non-occurrence of disease in the future). This makes the patient, who actively “knows” that they have been saved from disease and so expresses gratitude to the practitioner, a rarity in preventive medicine. This difficulty is highlighted by Threlfall *et al.* in their study of GDP attitudes to prevention (Threlfall *et al.*, 2007). Finally, there is a low tolerance for adverse risks for such interventions. A prime example of this is water fluoridation; potentially the individual who may not be at risk of the disease (dental caries) is put at risk of developing a complication (dental fluorosis) because of the intervention.

1.2.4.4 Common Risk Factor Approach

It has been noted that oral health improvement efforts have previously compartmentalised oral health from general health issues. These narrow approaches lead to conflicting health improvement messages being delivered to the public. This criticism is addressed by the common risk approach, recognising that many chronic non-communicable diseases such as; obesity, cardiovascular disease, cancers, diabetes and oral diseases; share a set of common risk factors. For example, In relation to dental caries, diet is a significant risk factor, which also is a risk factor for obesity, diabetes and cancer. Taking a common risk factor approach to diet would ensure that the health message delivered was appropriate for all these diseases, and not just reducing one element, i.e. sugar to improve oral health, at the detriment of another, i.e. increased salt consumption which is potentially detrimental to cardiovascular health (Sheiham and Watt, 2000; Watt, 2005).

1.2.4.5 Social Determinants of Health

Traditionally, health professionals have concentrated on preventive and educational interventions which attempt to alter the behaviours of the individual. The theory behind this approach being that once the individual gains the relevant knowledge and skills, they will alter their behaviours to maintain oral health.

The flaw in this approach is firstly knowledge gain alone rarely leads to sustained changes in behaviour and secondly it assumes that lifestyle choices are free and easily changed. The reality is that an individual's behaviours are enmeshed within the social, economic and environmental conditions under which they are living and to achieve sustainable change this wider context must be understood; this is especially true for children (Watt, 2007).

In taking into account the wider environment a child lives in and its impact on their oral health, Fisher-Owens et al. proposed a model for the influences on the oral health of children from the United States of America (USA) (see Figure 1). This builds on Watt's social determinants of health to create an inclusive and dynamic model for oral health of children (Fisher-Owens et al., 2007).

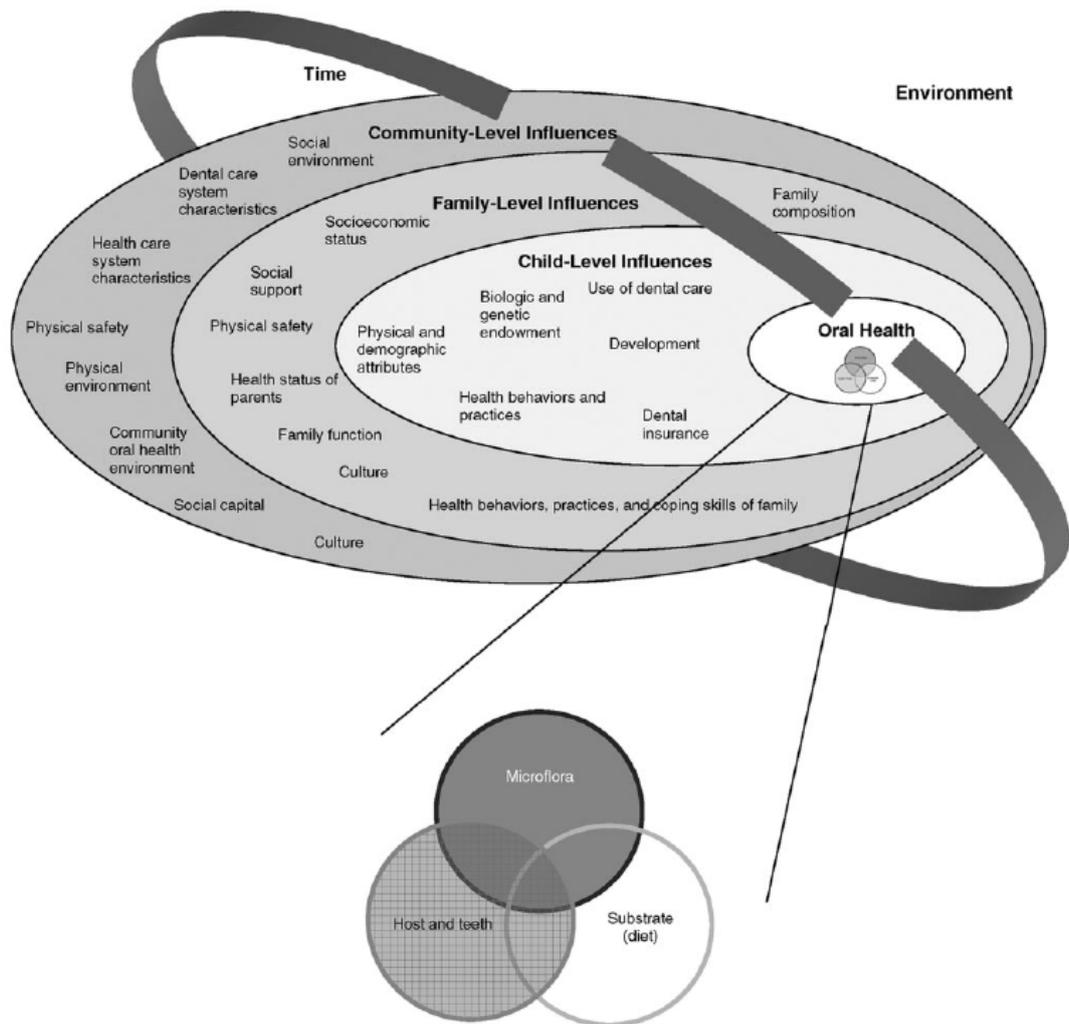


Figure 1 Conceptual model of child oral health
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This model encapsulates multifactorial influences on child oral health from the level of the individual, through to family and community and also recognising that these influences are dynamic in nature, changing in time. Models such as this enhance the appreciation of the complex interactions that exist between determinants of oral health and hopefully facilitate the development of nuanced oral health interventions. This model also demonstrates that an individual clinician has only limited ability to address all these factors, in order to affect this wider system and so facilitate improvement to health, a larger multidisciplinary approach is required.

1.2.4.6 Ethical Aspects of Health Promotion

The use of targeted or universal approaches to preventive medicine raises several ethical questions. Whilst within the population as a whole there may be

a smaller proportion with high levels of disease, potential interventions which target the whole population will shift the mean level of disease not only for those at the high end of the spectrum, but also for the rest of the population with low levels of disease. Unfortunately, an additional level of complexity arises when it is socioeconomic inequalities that drive the uneven distribution of the disease. In these situations a universal approach may at best only maintain the inequalities in disease distribution, or may even worsen the inequalities, as those most in need of the intervention may be the least likely to effectively participate in it.

In contrast, a targeted approach may bring the relative level of disease burden within the socioeconomically deprived group more in line with the population as a whole. Allocating resources in this targeted fashion may reduce health inequalities, but may not give the greatest potential health gain possible. Balancing the drive to reduce health inequalities against the possibility that targeted interventions may be more costly or less cost-effective, is one of the difficult questions those responsible for commissioning such services need to contemplate (Batchelor and Sheiham, 2002; Milsom and Tickle, 2010; Shaw et al., 2009).

1.2.5 The Scottish Experience in Oral Health Promotion

1.2.5.1 The Glasgow Pre-5 Year Old Oral Health Gain Project

In 1996, the Greater Glasgow Health Board commissioned an Oral Health Needs Assessment (Blair et al., 2006, 2004). This demonstrated that infants living in the G22 postcode area (Possilpark, Parkhouse and Milton), a particularly socioeconomically deprived area, suffered from high levels of poor oral health. This was in spite of established dental health education programmes in Greater Glasgow. Therefore, in an attempt to improve the oral health of children in this community, the Greater Glasgow Health Board commissioned a four-year Pre-5-Year-Old Oral Health-Gain Project in the G22 area. The project adopted the principles of the Ottawa Charter, advocating multi-agency working that enabled community development of interventions that fostered supportive environments aimed at improving the determinants of children's dental health.

Local parents, carers and opinion-formers who lived and worked in the G22 area helped identify lifestyle issues they believed held prospects for local modification. Existing community structures and resources were utilised to support various interventions, for example; breakfast clubs, fruit distribution schemes, milk-token initiatives, food-tasting sessions, free fluoride toothpaste distribution and arts and crafts activities.

Local community-based health campaigns were organised focusing on early nutrition, regular oral hygiene, use of fluoride toothpaste and “The Friendly Dentist Scheme”. Breast feeding was encouraged and parents and carers were cautioned regarding putting sugar containing liquids in the nursing bottle and discouraging frequent consumption of sugar containing drinks by children. These messages were supported by distribution of free infant drinking cups, introduction of agreed snack and meal policies into child care environments and the free provision of toothbrushes and toothpaste.

Outcomes for the pilot project were measured by comparison of cross-sectional epidemiological studies of children in G22 compared with another post code area of similar demographic, G33. This was done at baseline (1995/96), two-years (1997/98) and four-years (1999/00). Amongst 36-47 month-old children in G22 there was a 46% reduction in mean decayed missing or filled deciduous teeth (dmft) from 3.9 (95% CI 2.8-5.1) in 1995/96, to 2.1 (95% CI 1.6-2.6) in 1999/00. Whilst in the 48-59 month-old children in G22 there was a 37% reduction in mean dmft from 5.9 (95% CI 5.1-6.8) to 3.7 (95% CI 3.1-4.3). In the 36-47 month-old children, the proportion with dmft = 0 increased from 38% to 51% ($p=0.078$) and for 48-59 month-old children, from 17% to 40% ($p<0.0001$) (See Figure 2 and Table 1).

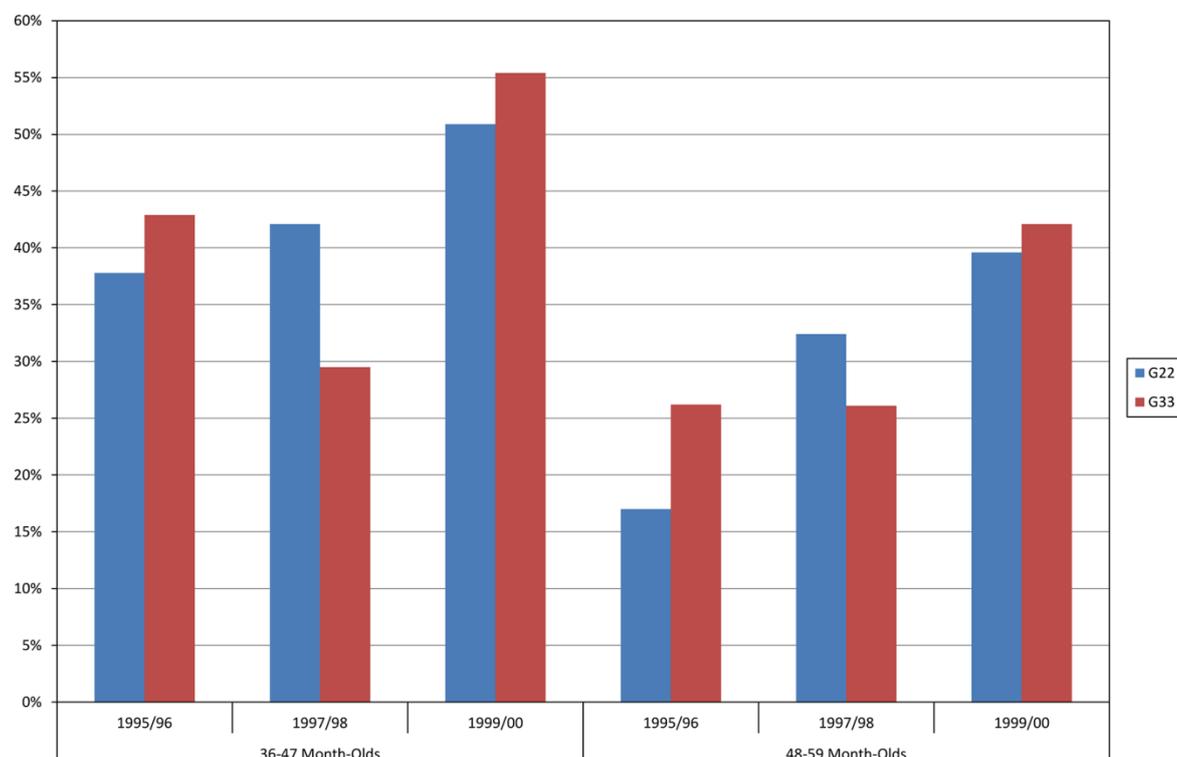


Figure 2 Glasgow Pre-5-Year-Old Oral Health Gain Project - Percentage dmft = 0

Table 1 Glasgow Pre-5-Year-Old Oral Health Gain Project - Percentage dmft = 0

		36-47 Month-Olds			48-59 Month-Olds		
		1995/96	1997/98	1999/00	1995/96	1997/98	1999/00
G22	<i>dmft = 0</i>	37.8%	42.1%	50.9%	17.0%	32.4%	39.6%
G33		42.9%	29.5%	55.4%	26.2%	26.1%	42.1%

The positive results from the pilot project area G22 prompted local activists in the comparison area G33 to initiate their own local oral health improvement programme in 1998 and for the Greater Glasgow Health Board to consider that it would be unethical to withhold the interventions from the comparison area. This can account for the trends seen in Figure 2, with G22 showing sustained increases in the percentage of children with dmft = 0. Whilst G33 initially shows a fall in the percentage of 36-47 month-old's with dmft = 0 between 1995/96 and 1997/98 and for the percentage 48-59 month old's over the same period result remain static. In G33 the 1999/00 results appear to show the impact of the introduction of the local oral health improvement programme to this area, with the percentage of children with dmft = 0 increasing in both age groups.

The evidence from this pilot project suggests that the community interventions within the project were responsible for improvements in pre-5-year-olds oral health; especially as the areas involved bucking a generalised trend for poorer

infant dental health in similarly deprived areas of Glasgow. Part of this success may be due to the support the project offered to communities to implement change and modify lifestyles, in contrast to more conventional oral health education programmes.

1.2.5.2 Childsmile

Childsmile began in January 2006 as the national child oral health demonstration programme in Scotland (Macpherson et al., 2010b; Shaw et al., 2009; Turner et al., 2010). The Childsmile programme was a key policy development from the Scottish government's "Action Plan for Improving Oral Health and Modernising Dental Services in Scotland" and is also based on the health promotion framework set out in the Ottawa Charter (Scottish Executive, 2005). As such, Childsmile is a comprehensive health promotion intervention, which includes community development activities and service redesign as major components. It is not simply a dental health education programme. Furthermore, the interventions employed in the programme are based on the experiences gained from previous projects, like the Glasgow Pre-5 year old oral health gain project. The programme has three main arms: Childsmile Core; Childsmile Practice; and Childsmile Nursery/School.

1.2.5.3 Childsmile Core

This a Scotland wide initiative involving, the free distribution of toothpaste and toothbrushes to every child in Scotland on at least six occasions during their first five years; along with the offer of free daily toothbrushing to every 3- and 4-year old child attending nursery in Scotland. Additionally, the toothbrushing programme is available to primary 1 and 2 classes of schools situated in disadvantaged areas of NHS Boards across the country.

1.2.5.4 Childsmile Practice

This initiative focused on children (and parents) from socioeconomically deprived areas, as determined by the Scottish Index of Multiple Deprivation (SIMD), and was initially piloted in the west of Scotland. It involved health visitors undertaking a caries risk assessment, as part of their routine assessment of all new born children. These health visitors, or public health nurses as they

are now called in Scotland, are based in the community and visit people in their home. They monitor the development of all new born babies and advise on health related matters to parents. They arrange for the provision of additional support for those with greater needs; therefore, those deemed to be at risk of caries are referred into the Childsmile Practice Programme. Initially, additional support is offered via a dental health support worker, who facilitates regular attendance at a local NHS dental practice; provides additional dental health advice and information in the family home; and links families into other community oral health improvement initiatives.

When the new born child attends the dental practice, trained dental nurses provide toothbrushing instruction and diet advice. As the child gets older, the dental practice team continue to provide toothbrushing instruction and diet advice, along with additional preventive interventions such as fluoride varnish and fissure sealants. Initially the programme was to focus on infants under three years; but as of October 2011 it has been incorporated into the routine NHS dental contract for all children up to 5 years. This means that GPs working for the NHS can now claim additional fees for carrying out preventive interventions under the Childsmile scheme (The Scottish Government, 2011).

1.2.5.5 Childsmile Nursery/School

This element of Childsmile is an additional series of targeted initiatives whereby the most deprived 20% of nurseries and school in each health board area, initially in the east of Scotland, are involved in extra preventive initiatives. In the targeted locations teams apply twice yearly fluoride varnish to the children's teeth. These teams comprise training extended duties dental nurses, who have undertaken additional training to apply fluoride varnish, and dental health support workers. The Childsmile teams also deliver oral health promotion advice to parents and carers. In addition this arm of the programme contributes to the creation of a health-promoting environment within nurseries and primary schools and provides additional pathways of referral into dental services for those who have not yet accessed them.

1.3 Quality Improvement in Healthcare

1.3.1 What is Quality Improvement?

Donald Berwick, former CEO of the Institute of Healthcare Improvement, was one of the first to propose the use of quality improvement methodologies in healthcare in his 1989 editorial in the *New England Journal of Medicine* (Berwick, 1989). Here he described traditional improvement methodologies as the “Theory of Bad Apples”. He described this as inspecting the outcomes – if a poor outcome is detected its producer must be removed/disciplined. This may also be called “quality by inspection” and Berwick suggests that this leads to a negative response from producers. The negative response being; producers will attempt to ensure that their outcomes are good enough to be judged acceptable, but it does not encourage anything beyond that. It also encourages producers to do what they can to distort the measurement, as this will be seen as the enemy by the producer. This results in negative competition between producer and inspector, with each one attempting to prove the other wrong.

Berwick suggests that the fallacy underpinning “quality by inspection”, is that it assumes producers with poor outcomes actively intended to behave in such a fashion, meaning you need deterrents to stop such behaviour. Berwick counters that this is a false notion. Instead he proposes that a poor outcome is the product of a poor system of work; that potentially any individual put into identical circumstances would produce the same poor result, meaning it is not generally the fault of one poorly performing individual. By removing this aspect of individual blame and instead focusing on the system, which can be the paperwork, the work flow, the inter personal relationships, etc., required to carry out a task, improvements in outcomes can be perused in a collaborative positive manner, rather than a competitive negative one.

Whilst there are many different terminologies, improvement techniques and measurement processes; the fundamental requirement to achieve quality improvement is the cultural change to move away from negative competition of “quality by inspection”. Instead a collaborative quality culture needs to be fostered, where everyone knows and understands their role in achieving the quality goals of the organisation. Where individuals know and understand how

their working processes impact on other members of the team and on the eventual outcome. Where everyone is engaged and empowered to deliver the changes that will result in improvement.

It is difficult to definitively define what a high-quality healthcare system would look like (Seddon et al., 2006b). Part of this is because of the differing perspectives of those involved in the provision of healthcare. Politicians and managers involved in healthcare look at the overall quality of the healthcare system and ensure that resources are distributed throughout the system in an effective and equitable manner. The front line healthcare staff are concerned with provision of the best care of the individual patient, in a safe and timely manner. In addition different patients will have different views on what “quality” is. For instance, for a patient with a chronic disease it may be to prioritise effective coordination of their care; whilst for a patient awaiting elective surgery it may be waiting times.

The language of quality improvement (QI) can often appear removed from the realities of patient care. However, if medical professionals cannot understand, much less lead, the debate on quality improvement, they risk losing out to competing economic and political interests in healthcare (Blumenthal, 1996). This loss of leadership could result in medical professionals no longer being masters of their field and also lead to loss of respect from patients that their current technical mastery affords them.

1.3.1.1 A Definition of Quality Improvement

Walshe undertook a review of the healthcare literature in an attempt to identify a commonly accepted definition of quality improvement (Walshe, 2009). Whilst a significant degree of heterogeneity was found in the terminology used, Walshe identified that the majority of the difference between these quality improvement terms is purely superficial and generally reflects a different terminology or emphasis on a common set of concepts. He highlighted four themes common to most of the different quality improvement terms:

1. They use the concept of a cycle of improvement.

2. They utilise a common set of quality improvement tools and techniques in each stage of this cycle.
3. They identify the importance of a corporate/organisational/systems dimension to improvement.
4. They recognise the importance of the buy in of front line staff in the quality improvement process.

Fundamentally, organisations and individuals should take the time to develop an understanding of and capacity to support a quality improvement methodology, without being hampered by differences in terminology. Walshe does suggest that the evidence base for quality improvement methodologies needs to be better organised, with a clear terminology used and that deficiencies in the evidence base need to be addressed.

Despite this lack of clarity in terminology of QI methodologies, a consensus now exists as to what quality in healthcare is. In 2001 the United States Institute of Medicine issued a landmark report called “Crossing the Quality Chasm”. This proposed six dimensions to healthcare quality and represents the most widely accepted definition of healthcare quality (See Table 2) (Institute of Medicine, 2001).

Table 2 Dimensions of Healthcare Quality

Dimension	Definition
Safe	Avoidance of harm
Timely	Avoidance of unwanted waits or delays
Efficient	Cost-effective
Effective	Use of evidence-based medicine
Equitable	Quality of health care should be the same regardless of social background
Patient Centred	Measure of the patient’s experience of healthcare, including control, privacy, dignity and lack of fear

1.3.1.2 Relationship with Evidence Based Medicine

When introduced as a concept, evidence-based medicine was presented as a method of providing a factual basis for the interventions and/or advice clinicians provide to patients (Evidence-Based Medicine Working Group, 1992). Ideally, this means when giving a patient advice on potential outcomes it can be

numerically quantified, rather than given in subjective terms like “In my experience it is likely that...”, which are open to potentially differing interpretations by clinician and patient. However, it has also been pointed out that definitive evidence is unlikely to exist in all circumstances and that clinical experience and intuition still remain important skills (Smith and Pell, 2003). An example of this being the “hunch” of a health visitor being one of the best overall predictors of future caries risk (MacRitchie et al., 2012).

To understand how evidence based medicine and quality improvement are related, it is useful to discuss the argument Gorovitz and MacIntyre made about medical fallibility (Gorovitz and MacIntyre, 1976). They argued that it is an inherent property of science that there remains knowledge that is unknown. As medical practice is the application of medical science, this limitation of scientific knowledge carries over to patient treatment and can lead to errors in patient treatment. They classified errors into two types; “errors of ignorance” – that is errors due to the limitation of current scientific knowledge; and “errors of ineptitude” – that is wilful or negligent application of erroneous scientific knowledge.

To complicate matters further, there is also an inherent fallibility to the application of medical science to the individual patient. It is a feature of scientific inquiry that strives for the elicitation of generalizable knowledge. However, the individual patient has so many unique features, making the application of this generalizable knowledge inherently uncertain. It is in this environment of uncertainty that quality improvement should aim to develop systems that minimise the second type of error– errors of ineptitude. With those involved in quality improvement having awareness that the first type of error– errors of ignorance, are consequence of the uncertainty of medical practice. As uncertainty will continue to be an element of medical practice, clinicians will be required to make intuitive decisions. Hall’s review on the topic recommends that clinicians gain a deeper understanding of how they are arriving at these intuitive decision, as to be aware of the potential biases that may have incorporated into their decision process (Hall, 2002).

Kitson *et al.* suggest a framework for implementing research into clinical practice, with successful implementation being a function of evidence, context,

facilitation (Kitson et al., 1998). They proposed that instead of visualising the relationship between these elements as a hierarchy or even linear relationship, they must be considered simultaneously (See Figure 3).



Figure 3 Elements of Implementation of Quality Improvement

They defined each of these elements in the following fashion:

Evidence - This can be derived from research, clinical expertise and patient choice. These can all be of poor or high quality, with high quality evidence in all these areas being the ideal for facilitating implementation.

Context - The environment or setting in which the proposed change is to be implemented, which can be subdivided into the prevailing culture, the nature of human relationships and the organisations approach to monitoring of systems and services. To produce generalizable evidence, conditions surrounding an experiment are controlled to be ideal as possible, i.e. exclusion of subjects with potentially complicating health conditions from clinical studies. By its very nature quality improvement cannot be so controlled; yet it is the conditions surrounding it that will greatly influence its success.

Facilitation - This is a person who facilitates change by generally making it easier for others. This is different from an opinion leader (See 1.3.10.1 Diffusion

of Innovations, Page 58) who whilst they may be respected within the organisation and their opinion highly valued, they may not facilitate change for others. The characteristics of a good facilitator are openness, supportiveness, approachability, reliability, self-confidence and the ability to think laterally and non-judgementally. Clarity around the facilitators role, status and intended purpose are vital as are the skills, knowledge and style of the facilitator.

Out of these three elements it could be argued that only the first, evidence, has been prioritised by medical researchers. This is likely partly due to the biomedical revolution that occurred in the mid-twentieth century.

“We were fooled by penicillin.” – Atul Gawande

The advent of the age of penicillin in the 1940s heralded an era where the prevailing ethos in medical research was it would be the discovery of new knowledge that would be challenging. This discovery would result in interventions where the application would be easy; all that would be required would be giving the patient a shot, a tablet or an operation. However, the reality has been that as we gained new knowledge and learned to treat the previously untreatable, the complexity of applying all this medical knowledge has increased exponentially. In the 1970s the average patient’s hospital admission in the USA required the care of an estimated 2.5 full time staff, by the 1990s this estimate had increased to 19.5 full time staff (Atul Gawande, Unpublished Data). Delayed dissemination and uptake of the latest evidence appears to be a major problem of this increasing complexity, with studies finding that it can take an average of 17 years before new evidence is widely practiced (Balas and Boren, 2000).

This increasing complexity has made it necessary to actively peruse QI research that targets the “context” and “facilitation” to ensure the best clinical evidence is successfully applied in all situations. Healthcare researchers are beginning to address this knowledge gap, by undertaking trials that attempt to modify behaviours in the clinical environment. The key literature from this nascent field of research is discussed in section 1.3.7 (See Page 49).

1.3.1.3 Differences between Research, Audit and Improvement

Clinical research is directed at filling the gaps in clinical knowledge that would improve patient care, whilst quality improvement is directed at addressing the gap between current clinical knowledge and actual clinical care. Clinical audit, whilst a form of QI, is primarily a form of benchmarking – in that an aggregated assessment of performance is compared to an agreed standard (Seddon et al., 2006c). This often proves useful in assessing the need for improvement, but as a method for driving the development of improvements audit has distinct drawbacks. Primarily its usefulness is limited, because the aggregate data produced by audit is insensitive to the day to day changes required to develop sustainable improvement. The Cochrane Collaboration undertook a review on the subject of “Audit and Feedback”, with feedback defined as “any summary of clinical performance of health care over a specified period of time” (Jamtvedt et al., 2006a). They found that whilst audit and feedback can be effective in improving performance, the effect was generally small to moderate. The impact of audit was greatest when baseline compliance was low, or when feedback was given more intensively; a feature with similarities to QI. A summary of the differing features between research, audit and quality improvement, is given in Table 3.

Table 3 Differences Between Measurement Protocols for Research, Audit and Improvement

	Research	Audit	Improvement
Sample Size	Large as possible	Large as possible	Just enough
Sample Selection	Truly random	Ideally random	Quick
Time Period Between Samples	Long	Long	Short
Measurement Points	Few (beginning and end)	Beginning and end, Multiple cycles	Multiple
Measurement Protocol	Strict and Regimented	Strict	Opportunistic and Convenient
Bias	Actively minimised	Minimised	Tolerated

1.3.1.4 Ethics and Quality Improvement

The situation regarding how quality improvement projects relate to traditional research and therefore traditional research ethics is becoming increasingly blurred. Pronovost *et al.* completed a multi-centre project looking at implementation of a checklist of catheter insertion in intensive care and its

impact on catheter infection rates (Pronovost et al., 2006). After publication of their report, the United States Office for Human Research Protections (OHRP) received a written complaint that the team had violated United States federal regulation of research ethics. OHRP ruled that the project need to be reclassified as research on human subjects, rather than service evaluation and provided the following guidance:

“A hospital can introduce a checklist system without IRB review and informed consent, but if it decides to build in a systematic, data-based evaluation of the checklist’s impact, it is subject to the full weight of the regulations for human-subjects protection.” (Miller and Emanuel, 2008)

This decision has created great debate as it raises several issues (Baily, 2008). Firstly, there was no confidential information used in the report. The intervention was purely the systematic implementation of what is known to be best clinical practice; hence it can be argued that it is not necessary or ethical to ask patients or clinicians to opt in or out. The report investigated the impact of the checklist on an organisational level, not at an individual patient level. It appears that OHRP’s concern is not with the intervention itself, but rather collecting and using data to guide such an implementation. This raises questions of what level of ethical oversight is required when performing such interventions (Birnbaum and Ratcliffe, 2008).

Within the UK guidance has been issued by the National Research Ethics Service (NRES) on the differentiation of audit, service evaluation and research (NRES, 2007). It broadly states that due to a general lack of clarity in relation to the use of different terms, a judgement will need to be made in some cases. The primary determinant of research ethics committee involvement should be the potential consequences. So that activities that carry a potential risk to participants should be formally reviewed, whilst those that carry no or negligible risk need not come before a full committee meeting.

An important thread in the argument for pursuing quality improvement, is that by making health care more efficient, it will help address the escalating costs of healthcare (Kofke and Rie, 2003). However, to do this quality improvement is

going to have to become involved with three fundamental medical practices, with potential difficult ethical implications, these being:

1. Doing everything possible for an individual patient regardless of risks or benefits to society as a whole.
2. Expending resources on healthcare interventions with marginal benefit to patient or society.
3. Applying high-tech interventions to conditions that could be treated in a less costly manner.

The impact of the ethical issues resulting in the attempt to address these difficult issues, can easily be seen in the controversy that surround decisions on whether the NHS should fund new and expensive drug therapies for conditions like cancer (Press Association, 2010), or should use less costly alternative medications off label (BBC News, 2012).

It is an increasingly regulatory requirement that healthcare professionals undertake quality improvement activities (General Dental Council, 2010; General Medical Council, 2012). There is a strong ethical argument that healthcare professionals and organisations should be doing all they can to ensure delivery of high quality care. One important element of high quality care is cost effectiveness, and so cost containment interventions would fall within the realm of quality improvement (Tomson, 2009). An example of a cost containment intervention would be sticking with a cheaper older therapeutic instead of the latest more expensive version, supported by a marginal benefit relative to cost. However, as it could be argued that by limiting access a more effective therapeutic, despite how marginal the benefits may be, you are potentially harming patients would therefore require conventional ethical oversight.

In the majority of cases a clear distinction between research and QI can be made, often due to an established evidence base and a lack of risk to patients. However, some grey areas remain, examples being around marginal benefits of less established treatments, informed consent, and conflicts of interest. However, as often decisions regarding the intervention, e.g. whether to

implement an intervention or not, are made by a different part of the organisation than that would study its impact, a potential way forward may exist for these more challenging situations. As if the intervention is going to occur regardless, a strong argument can be made that not studying the impact may also be inflicting a different type of harm to patients— by not evaluating such interventions useful knowledge is lost and potential harm unrecognised (Gawande, 2007). Yet, enforcing the traditional safe guards of research, such as informed consent, in such situations would be all but impossible (Miller and Emanuel, 2008).

1.3.2 Aims in Quality Improvement

Aims need to be specific, as it is more likely that a clearly stated aim will be achieved (Berwick, 1996). Therefore, it is the responsibility of those leading the improvement project to clearly articulate the aim of the project. The aim should be repeatedly restated throughout the duration of the improvement project to avoid mission drift. As it can be too easy to be distracted by the latest challenge, before the original aim has actually been met. Aims also need to be ambitious enough that it would be impossible to meet them by simply working harder, consequently challenging the team to fundamentally redesign the system.

When developing an aim for an improvement project the following questions should be answered (Langley et al., 2009):

- **What** are we trying to improve?
- **Why** do we need to improve?
- **Where** is the improvement going to occur?
- By **when** will the improvement occur?
- By **how** much will we improve?

If these questions can clearly be answered at the start of the improvement project, then clarity of propose is more likely to be established from the start, which should aid in achieving a successful outcome.

1.3.3 The Plan-Do-Study-Act (PDSA) Cycle

The PDSA cycle is part of “The Model for Improvement” proposed by Langley *et al.* as a structured methodology for developing changes for improvement (Langley et al., 2009). The driver behind the model is three questions (See Figure 4). The improvement effort should result in answers to these three questions. These answers may be obtained in a variety of different ways and will likely require multiple attempts/refinements before coherent answers are discovered.

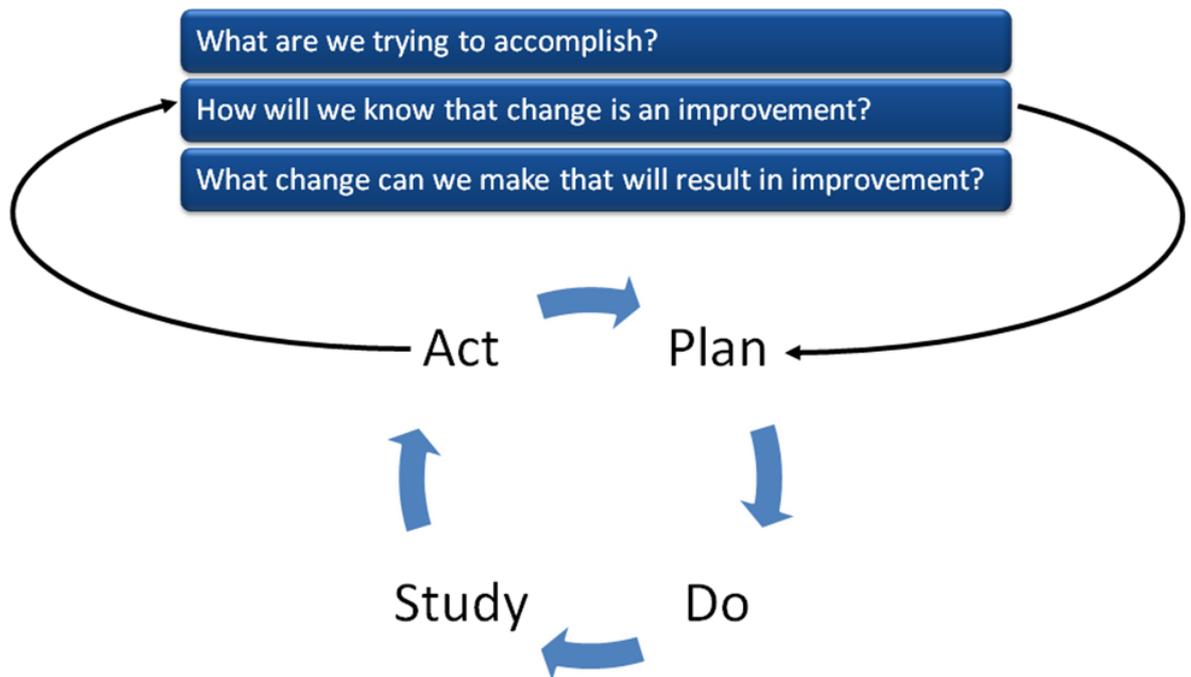


Figure 4 The Plan-Do-Study-Act (PDSA) Cycle

The stages of the PDSA cycle consist of:

- *Plan* - A learning opportunity, test, or intervention should be planned out. This plan should include:
 - The question(s) to be answered by the test.

- A clear prediction of the expected outcome, with a reason why the outcome is expected.
- A method to collect the data that will provide the answer to the question(s).
- *Do* - The plan should be carried out, with data collected as designed, but also importantly data collected about those things that may have occurred because of the test but were not predicted/expected to occur.
- *Study* - Time needs to be set aside to review the results of the test, to determine if the predicted outcome occurred and what unexpected results were found.
- *Act* - The knowledge gained from reviewing the results of the test should be acted upon in a rational manner.

As mentioned previously (See 1.3.1.3 Differences between Research, Audit and Improvement, Page 36) this appears similar to the conventional audit cycle (See Figure 5). However, PDSA cycles are concerned with rapid change, but also with a rough form of hypothesis testing incorporated. In effect the predicted outcome made at the “plan” phase acts as a rough hypothesis. This hypothesis will be tested at the “do” phase and it is important that time is taken at the “study” phase to determine whether, in a non-rigorous fashion, the hypothesis was proven or not by the test. In improvement projects rigorous statistical tests will not be applied to the data to prove or disprove a hypothesis, instead statistical processes control tool will be used to attempt to identify common and special cause variation.

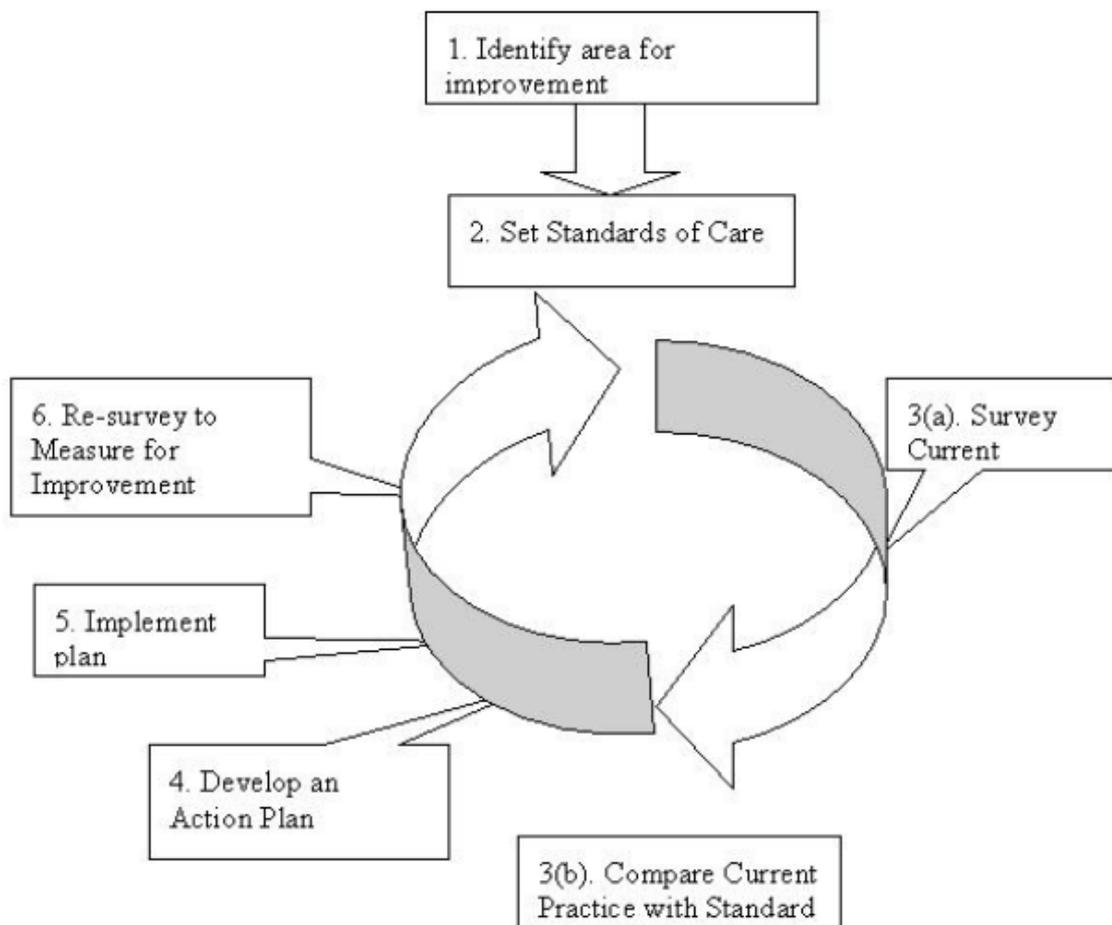


Figure 5 The Audit Cycle

From (Seddon et al., 2006a) reproduced with permission from *New Zealand Medical Journal*

The Model for Improvement advocates that the initial test for the first PDSA cycle should be done on as small a scale to make a preliminary assessment of the validity of your prediction, i.e. one person, one time. The knowledge gained from this first cycle should then guide the improvement team as they carry out repeated cycles whilst scaling up their intervention, i.e. from 1 to 3 to 5 to 10 to 20. In the healthcare setting the initial test may be one person, but it may just as well be one team, depending on the situation. The change can be made to work for one individual/group in a particular setting, before being gradually spread to others in different settings.

1.3.3.1 Other Quality Improvement Methodologies

Many different quality improvement methodologies exist, as highlighted by Walshe (See 1.3.1.1 A Definition of Quality Improvement, Page 31), all with differing terminologies and emphasis on differing concepts (Walshe, 2009). A list of some of the main quality improvement methodologies is included in Table 4.

Table 4 Other Quality Improvement Methodologies

Quality Improvement Methodology	Description
Lean	An improvement methodology that aims to improve value by eliminating wasteful processes.
ISO 9000	A family of quality standards set out by the International Organisation for Standardisation (ISO).
Total Quality Management (TQM)	The main element of TQM is that everyone within an organisation is responsible for the quality of products/services produced.
Continuous Quality Management (CQM)	The main focus of CQM is that the performance of systems within an organisation have to be continually managed to ensure quality is improved and maintained.
Process Re-engineering	This is a top-down approach to quality improvement, involving fundamental rethinking and redesign of organisational systems.
Six Sigma	Six Sigma priorities demanding statistical analysis and systematic problem solving.

All of these methodologies have a cycle of improvement similar to the PDCA cycle at their core (James, 2005). The model for improvement is very similar to TQM and CQM, with the difference between all three primarily being one of terminology used. Six sigma is also similar to the model for improvement, but more focused on complex statistical models along with developing a specialised hierarchy of six sigma “specialists” within an organisation. ISO 9000 is an internationally agreed group of standards related to quality management, which organisations can become certified as complying with - often a requirement of purchasing organisations. It primarily focused on policies that an organisation should have in place, not on how improvement should be achieved.

Process re-engineering is a method of rapidly inducing radical change, generally by senior management empowering employees to redesign their work processes from scratch. Often this will use Lean to identify aspects of the current system that should be eliminated in the new design. Process re-engineering is very resource intensive for an organisation to undertake and so only done so when an identified need for change exists. Fundamentally, the choice of which QI system

to use will be driven by the type of situation being addressed, along with the priorities and existing QI skills within an organisation.

1.3.4 Measurement in Quality Improvement

To learn if a change has been effective, measurement is required. This measurement should be closely related to the aim of the quality improvement project and should be able to clearly demonstrate improvement in the area you are attempting to address (Berwick, 1996). Ideally, prospective data collection can provide the most useful data for answering these quality questions. However, unless the required information is easily extractable, for example from electronic records, it can again be costly to incorporate data collection into routine patient care. Collection of high quality outcome data for quality improvement can add additional complexity and expense to any such project. Some of the most potentially useful measures would require following up patients over several years, which is generally beyond the scope of quality improvement projects (Krumholz et al., 2000).

Designing the measurement is as important as designing the intervention in a quality improvement project. Generally measures can be classified into either outcome, or process measures. Outcome measures deal with the outcome derived from a system, for example the number of infections, deaths or patient satisfaction. Process measures relate to measurements made of the system itself, for example hand washing rates, checklist completion, or drug administration. Along with selecting what type of measure you wish to use, measurement must be implemented at a suitable stage in the system to produce data that can be interpreted as being related to the workings of a particular part of the system. This interpretation will often rely on research, which may have already determined a cause and effect relationship between an intervention and outcome.

1.3.4.1 Common and Special Cause Variation

The concept of common and special cause variation comes from the work of Walter Shewhart, who worked at the Western Electric Company producing telephones in the 1920s (James, 2005). Here he faced the problem of reliability

of equipment being produced. Shewhart, a qualified physicist, identified that in manufacturing some processes will produce a range of results due to random chance, but will fundamentally be producing results within a normal range. A system producing results such as these should be considered stable, or under the effect of common cause variation. In contrast if a system is producing results beyond those attributable to random effect, these systems should be considered to be under the influence of special or assignable cause (Carey, 2002a).

Common cause variation - this is the range of results a stable system will produce due to random chance. A system producing results like this cannot be improved without changing the system itself.

Special cause variation - this results from influences that are new to the system and is having an attributable effect on the result of the system. Identification of the influence can be used to learn how to influence the system.

Neither type of variation can be considered intrinsically good or bad. Though common-cause variation ensures that the process is in control, the process itself may be unacceptable and therefore one may wish to cause special cause variation to occur as they change the system (Langley et al., 2009)

1.3.4.2 Statistical Process Control

The identification of common and special cause variation is of particular use in quality improvement projects, as it informs you on how the system is behaving. If you are looking to change how the system is performing; the intention will be to induce special cause variation. In contrast, if the intention is to maintain a level of performance; the requirement will be to maintain control of the system at the desired level of performance – if special cause variation is detected it will need to be eliminated (Berwick, 1996).

With summary statistics outcome measurements are generally computed with aggregated data, therefore a great deal of information about the performance of the underlying systems and subsystems disappears. Combining many variables, in an attempt to dilute out the effect of the context in which the data were collected, into a single aggregate result. This inhibits the ability to rapidly

identify and tackle process variability due to the context being examined. Therefore, summary statistics, whilst ideally suited to tests of significance when comparing large data sets, are of limited value when attempting to improve a dynamic system (James, 2005).

Statistical Process Control (SPC) is a methodology originally developed by Shewhart to identify common and special cause variation (See 1.3.4.1 Common and Special Cause Variation, Page 44). SPC techniques have the advantage of being able to track variability across time, with this long-term tracking revealing more information about the behaviour of the process. The two main SPC tools are the run chart and the control chart (Carey, 2002a, 2002b).

Both these types of chart are similar, in that they are a line chart plot of a measurement against time. For control charts an upper and lower control limit will be calculated from the data, with results beyond these limits indicative of special cause variation. Generating these control limits request either detailed knowledge of the underlying statistical methods or specialist software. There is a diversity of different types of control chart, with approximately 3 to 4 new types being developed each year (Benneyan et al., 2003). Selection of the correct type to use is a specialist skill in itself, as it depended on a number of factors, for example, the type of data collected, how it is collected and the distribution assumed for the data. Also a level of baseline data is generally required to produce these control limits, creating a delay before active change could be introduced (Oakland, 2003).

Run charts do not have these control limits; rather they have a centre line based on the median the data set and a target line. Special cause variation can be detected on run charts by the application of run chart rules; discussed later (See Methods - Run Charts). Run charts can be readily produced with common graphing software and have little demand on additional skills when compared to control charts (Clinical Indicators Support Team, 2011).

The demands of specialist knowledge constrain the routine use of control charts by healthcare professionals. However, they are particularly useful in monitoring the behaviour of established systems, so that results lying outside these limits can readily be identified and corrected. Run charts have a significantly lower

barrier to use, and so can more readily be produced and interrupted by healthcare professionals. Also, in projects where results are expected to be highly erratic, such as the one described in this thesis, the lack of control limits is of limited concern as they tend to encompass such a wide range as to render them meaningless.

1.3.5 Systems in Quality Improvement

“every system is perfectly designed to achieve the results it achieves”(Berwick, 1996)

The above quote refers to what Berwick called “the central law of improvement” and enshrines the principle that it is the system that is responsible for results. Therefore, if the wish is to improve results, it is the system that needs to change. A system being defined by Berwick as “any set of activities with a common aim”; in healthcare this common aim is the care of the each and every patient.

Looking at health care critically it is an extremely complex system, as there are multiple interconnected sub-systems (different members of the clinical team within a specialty, different specialties, administrators, managers, medical records staff, primary and secondary care, etc) that are all required to work together to provide care for the patient (Reason et al., 2001).

Increased effort can lead to some improvement in performance, but it does not lead to an improved capacity and therefore is not a fundamental improvement in quality. However, it is important to appreciate that even within an unchanged system, there will be variation in performance and this is why it is important to be able to identify between common and special cause variation (See 1.3.4.1 Common and Special Cause Variation, Page 44).

A key concept in changing systems to improve safety or quality, is to have an understanding of your system so that you can then design it in such a fashion as to maximise potential for a positive outcome and minimise potential for a negative one. A prime example of this system design being the process of withdrawing cash from a cash machine. The designers of the machine know that the user is using the machine to withdraw cash. Therefore, the user is very

unlikely to leave the machine without first collecting their cash. However, the user is potentially very likely to leave the machine before collecting their bank card. The designers have negated this potential problem by engineering the process of using a cash machine, so that the critical step of receiving cash cannot be reached without first collecting the bank card. Within any quality improvement project, the identification of these natural pause points and critical step is highly valuable, as they can be utilised in a similar fashion to build in the desired result into the system (Ely et al., 2011).

1.3.6 Developing Changes in Quality Improvement

Langley *et al.* discussed the fallacy of certain methods for developing change (Langley et al., 2009). These included; “more of the same”, as they argue that putting more resources into the same system, will only produce more of the same results. Whilst, attempting to develop “the perfect change” is suggested as a path to inaction; due to endless planning and discussion. Finally, they discuss the adage “if it ain’t broke, don’t fix it”, an argument for not changing. Whilst this may be appropriate in situations where all influences and elements in the system are truly static; in truth nearly all organisations face a host of dynamic influences, both internal and external, that render being truly static an impossibility.

Instead they suggest a middle road of doing small tests of change. By doing something different once and measuring the result, you aim to develop a change, whilst avoiding the paralysis of attempting to develop the perfect change immediately. This change can then be refined over multiple cycles (See 1.3.3 The Plan-Do-Study-Act (PDSA) Cycle, Page 40), gradually increasing the size of the test at each cycle. In this way the confidence in the effectiveness of the change can gradually be developed, while at the same time knowledge can be gained about the dynamic issues that may only become apparent as the tests are scaled up.

1.3.7 Influencing Behaviour in Quality Improvement

There are a multitude of methods for influencing behaviour and a comprehensive list is beyond the scope of this thesis. However, for purpose of discussion some of the more common and/or pertinent are described below.

Many of the studies into the methods discussed below demonstrate around a 10% increase in the desired behaviour; improvements in this region are generally described as “modest” in the literature (Jamtvedt et al., 2006b; Shojania et al., 2009). A similar issue similar to that of the “prevention paradox” in health promotion presents here (See 1.2.4 Health Promotion, Page 20), in that a relatively modest improvement at the level of the individual clinician would have a big impact when multiplied nationally across a whole health service. As with the general public and health promotion, the challenge then becomes persuading clinicians to invest effort and potential behave differently than existing norms, for what may directly appear to them a rather minimal return.

1.3.7.1 Knowledge and Training

Two Cochrane reviews on the subjects of educational meetings and printed educational meetings on practitioner behaviour found that their impact was fairly minimal; in the region of 10% increase in desired behaviour versus controls (Farmer et al., 2008; Forsetlund et al., 2009). Though this is a minimal effect, having the required knowledge and skill to carry out the behaviour is fundamental to achieving behaviour change.

1.3.7.2 Reminders

Shojania *et al.*'s review on the impact of electronic reminders on practitioner behaviour found a small too modest improvement in desired behaviour (Shojania et al., 2009). Twenty-eight studies were included in their analysis, which found a median improvement in desired behaviours of 4.2% (interquartile range 0.8%-18.8%). The large interquartile range, from effectively 0% to almost 20%, indicates the heterogeneity of reported results. At present further research is required to identify the features of those electronic reminders that produce significant levels of behaviour change.

1.3.7.3 Financial Incentives

Using financial incentives is a commonly used method of influencing individual behaviour. One only has to visit their local supermarket to see a range of “special” offers which aim to influence your purchasing behaviour. Whilst behaviour economics have been examined since Adam Smith in the 18th century, the evidence of how this applies to healthcare practitioners, whose primary interest should be the altruistic welfare of their patient, is less clear. The Cochrane Effective Practice and Organisation of Care Group has undertaken a number of reviews of the topic, but has been unable to find any persuasive evidence in the area (Flodgren et al., 2011).

Clarkson *et al.* undertook an evaluation of financial incentives and educational interventions on dentists behaviour in relation to the placement of fissure sealants (Clarkson et al., 2008). This is one of the few trials in the field of behaviour change, which found the financial incentive to be effective, whilst the educational intervention was not. The effect of the financial incentive was a modest increase of 9.8% (CI 1.8%-17.8%) over the control group. Interestingly only two-thirds of the eligible dentists claimed the additional fee, indicating the existence of additional barriers beyond purely financial incentives. As discussed previously (See 1.2.2 Dental Care in Scotland, Page 17) differing payment methods are used across the different dental services in Scotland. How these different financial arrangements influence clinician behaviour is subject to frequent debate, but at present the limited evidence in this area is suggestive of only a modest effect.

1.3.7.4 Default Options

It has been demonstrated in many instances that people are more likely to choose the option that does not require action, whether that be opt-out marketing, organ donation, or pension schemes (Johnson and Goldstein, 2004). The power of default options is that it influences choice without limiting it, making their considered use a powerful tool. Part of this power arises from human’s natural bias towards the status quo, and greater fear of errors of commission rather than errors of omission. The power of the default option also increases as the relative difficulty of choosing the alternative rises, and it is this

element that needs to be treated with caution, as it can create a barrier to a free decision.

It can be argued that since default options can limit choice, their use in health care is a return to paternalistic medical practice. However, their use to some extent is unavoidable; the obvious situation is policies that expect a patient to be treated in a certain fashion and with deviation from the policy requiring justification as a method of maintaining equality between patients. Careful utilisation of default options in health care gives the opportunity to maximise benefit, whilst ignoring them leaves their powerful influence to chance (Halpern *et al.*, 2007). Situations also exist where non-obvious default options exist, for example initial settings on equipment that may not subsequently get adjusted; these require that thought be given to ensure that the default does the most benefit, or the least harm, to the majority of patients. An example of this is a study by Drakulovic *et al.* which shows that by setting the default bed position in an intensive care unit to 45° rather than 0° rates of pneumonia were significantly lower than the control group (Drakulovic *et al.*, 1999). In oral health care default options could be utilised for instance by having a policy where an application of fluoride varnish is prepared for every child patient attending for examination.

1.3.7.5 Checklists

One of the most persuasive recent safety innovations in health care has been the introduction of the World Health Organisation Surgical Safety Checklist. This checklist consists of 19 items, the main points being; a formal surgical team briefing, confirmation of patient identity and surgical site, administration of prophylactic antibiotics and pre-warning the team of any potential complications. The impact of this checklist was demonstrated in the study by Haynes *et al.* which reported the on the pre and post implementation rates of post-operative complications and mortality (Haynes *et al.*, 2009). The study was carried out at 8 different sites, ranging from high-income countries like the USA and UK, to low-income countries like Tanzania and the Philippines. What was found was that overall the rate of any complication fell from 11.0% at baseline to 7.0% after introduction of the checklist ($P < 0.001$), and that mortality fell from 1.5% to 0.8% ($P = 0.003$).

Checklists have been used for decades in other fields, where routine, yet critical, tasks are required to be done repeatedly, a prime example being the aviation industry (Gawande, 2011). Designing an effective checklist is a complex procedure and great care is required to ensure that the resulting checklist is effective. A well designed checklist will ensure the routine mechanics of a situation are properly handed, freeing those involved to apply their critical thinking to the non-standard elements of a situation. During critical incidents in the airline industry, individuals still have to make crucial decisions, requiring individual skill and decision making (Singh, 2009). The checklists provided them with a baseline level of confidence in what they need to do in order to maximise the team's chances of success, by helping to ensure that in the heat of the moment they did not miss a critical step.

Checklists are now being developed for a range of medical issues, including; childbirth (Spector et al., 2012), review of medication ordering (Meyer et al., 2011), oncology records (Albuquerque et al., 2011) and tuberculosis diagnosis (Field et al., 2011). Despite the evidence of the success application of checklists; there remains resistance in some quarters of medicine to the application of checklists to medical practice (Laurance, 2011). This resistance primarily originates from the perception that the use of checklists limits clinical autonomy. Also the primary focus of medical checklists reported in the literature to date, has been acute medicine and surgery. There is presently a paucity of literature on the use of checklists in primary care medicine, other than for diagnostic checklists, primarily of psychological conditions.

1.3.8 Barriers to Quality Improvement

An important part of any quality improvement intervention is the active identification of barriers that exist within the organisation that could/are preventing improvement from occurring (Langley et al. 2009). Once barriers are identified, it is the role of the quality improvement team to attempt to address them. However, it is likely that some barriers encountered will be beyond the scope of the quality improvement team to be able to effectively address. They may decide to modify their intervention to avoid the barrier, or may require the active support of organisational leadership to effect wider change to address the issue.

Radnor et al. surveyed the implementation of quality improvement interventions in a range of Scottish public sector organisations (Radnor et al., 2006). Whilst these barriers are particular to the public sector organisations surveyed, they hold important lessons for anyone looking to implement improvement in a large organisation (See Table 5).

Table 5 Common Barriers to Improvement in Scottish Public Sector Organisations
Adapted from (Radnor et al., 2006)

People	<p>Scepticism of staff to the latest management “fad”.</p> <p>Staff feeling that they would not be listened to and that nothing will significantly change.</p> <p>Fear that improvement programmes were targeted at cutting costs and jobs.</p>
Lack of ownership	<p>Managers/services Leads not understanding the improvement process.</p> <p>Unwilling to look outside their individual part of the process.</p> <p>Being too focused on operational matters to look at overall process.</p>
Identity of improvement team members	<p>Improvement teams can become dominated by managers, who are removed from the process; whilst front-line staff do not become involved, pleading time pressures.</p>
Failure of leadership	<p>Management needs to be clear on the driver of change, be honest about any constraints and actively support the implementation of change.</p>
Compartmentalisation	<p>An unwillingness to become involved in processes outside the persons immediate working environment.</p> <p>Weak link between improvement programmes and overall organisational strategy.</p> <p>It needs to be made clear how the aims and objectives of any improvement programme complement the overall strategy of the organisation.</p>
Lack of resources	<p>Lack of resources, both in terms of finance and knowledge, can significantly hamper any improvement project.</p>
Poor communication	<p>Avoid the use of quality improvement jargon which people outside the quality improvement team may not understand.</p> <p>A clear consistent message about the quality improvement project need to be projected to all staff.</p> <p>Information needs to be presented in a clear and constant fashion and not over controlled.</p>

1.3.9 Achieving Reliability in Quality Improvement

Healthcare is a complex mesh of inter-connected sub-systems (Reason, 2000). Part of the reason for these complex levels of systems is to act as a defence against the occurrence of errors, which means that when adverse events do occur there is usually a collective failing of multiple systems. The defences of the system can be visualised as different layers of Swiss cheese (See Figure 6), except that the position of the holes is continually changing. The existence of holes in one slice does not normally result in an adverse event as they are normally blocked by another layer. It is only when the holes in many layers line up that an error is able to progress through the system and result in an adverse event.

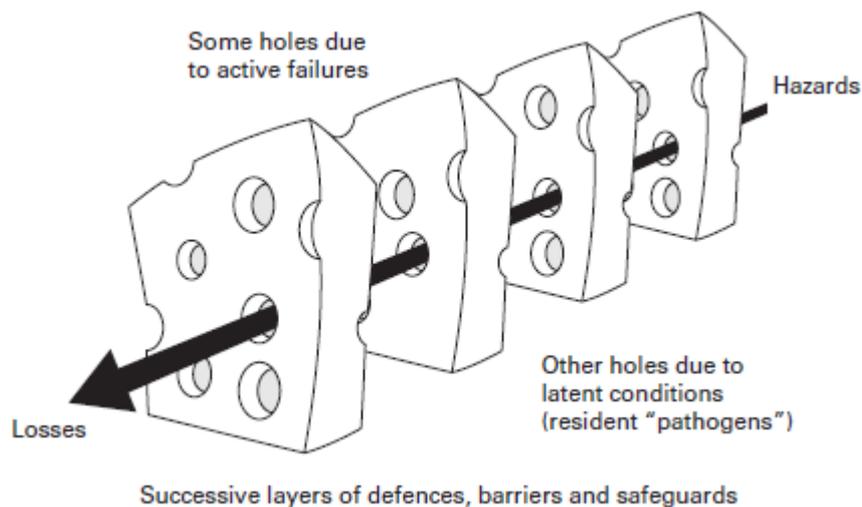


Figure 6 The "Swiss Cheese" Model of Accident Causation
 Reproduced from *Quality in Health Care*, JT Reason and MR de Leval, Vol 10 Suppl 2, Page ii21-25, 2001 with permission from BMJ Publishing Group Ltd.

There are two approaches to human error, the person approach and the system approach. In the person approach errors are primarily due to aberrant mental processes in the individuals providing the service. In this approach errors are treated as moral issues (See 1.3.1 What is Quality Improvement?, Page 30) and are therefore countered by attempting to remove unwanted variability in human behaviour through discipline, retraining, naming and shaming, etc. However, it is often the case that the best people make the worst mistakes, as their past competence makes them liable to take the biggest risks in the future. Mishaps tend to fall in recurrent patterns, therefore in similar circumstances the same result will occur in the future.

In the system approach, the basic premise is that humans are fallible and errors are to be expected. In this approach errors are seen to arise from human failings. However, it is flaws in the system which allows these failings to result in errors. The error is seen as a consequence of flaws in the system; rather than caused by human failings. Within this approach it is visualised that two components, active failures and latent conditions, need to interact to result in an adverse event. Active failures are the lapses of those at the sharp end of service delivery, resulting in direct, but usually short lived, degradation in the integrity of the system defences. Latent conditions are the resident weakness in the system integrity due to the conditions within the system. Examples being; staffing levels, time pressures, work flows, inadequate equipment, etc. Whilst not necessarily intentional, these latent conditions are generally introduced by those responsible for managing the system and can lie dormant for many years.

Reason et al. proposed the existence of “vulnerable system syndrome” (VSS), where the combination of blame, denial and the pursuit of the wrong kind of excellence, combine to create the conditions for adverse events. Blame relates to the human predisposition to blame individuals for failing, that is, if something goes wrong it was because the person doing it was careless or stupid. Yet, often the person involved with the event will have been constrained by the system/events that they feel forced to act in a certain way. There is also the common belief in the just world hypothesis, good things happen to good people and conversely it must be a bad person who carried out a bad act. The final element of blame is hindsight bias, what might appear obvious in retrospect, might not have even crossed the minds of those involved at the time as a potential outcome.

Then there is denial, which relates to how safety is managed within the organisation. The safest organisations will be generative, in that every level of the organisation will be constantly identifying weakness in the system and management will facilitate changes to address them. The least safe organisations are pathological, where responsibility for safety is shrunk from, whistle blowers maligned, new ideas ignored and failures covered up or punished. In the middle are the bureaucratic organisations, who do not discourage safety, but will compartmentalise problems rather than generalise and fixes will be localised rather than systemic.

Finally, there is the pursuit of the wrong kind of excellence, which in health care will generally mean a myopic focus on a limited number of performance indicators (waiting list times, etc), without concern for the bigger picture. Part of this is because people easily comprehend systems as a production line working linearly towards a goal, but struggle to comprehend the interconnected web that these systems usually are in reality. Therefore, they fail to comprehend the knock-on effects their actions may have on other systems that may appear initially unrelated to them.

Certain organisations (nuclear power plants, military aircraft carriers, air traffic control) are identified by Weick as high reliability organisations (Weick, 1987). These organisations have to deal with highly complex and demanding interconnected systems and any adverse event within the organisation could be catastrophic. Yet, the error rate within these organisations is remarkably low, resulting in the definition as highly reliable organisations. Weick identifies the following features of these organisations as being key to their success:

- They appreciate that human variability is not a negative that needs to be stamped out. Rather that it is this adaptability that allows the organisation to respond to the unforeseen.
- To them safety is “a dynamic non-event”, as maintaining safety requires constant adjustment but success results in avoidance of an event.
- These organisations, whilst having a strong hierarchical management structure, can effectively decentralise this management in times of crisis. This ability comes from the focus on developing a common culture within the organisation. This culture allows individuals within the organisation to be comfortable other team members in a crisis, as expectations on roles, responsibilities and common goals are well established in advance.
- Within these organisations there is a collective preoccupation with failure. They expect to make errors and so all levels of the workforce are trained to recognise and recover from them.

- When an error does occur, instead of isolating it, they will look to generalise it to the whole system to learn as much as possible from it.
- They have a strong organisational memory, so that the reasoning behind past decisions is remembered. This can be crucial if work from the past is being re-evaluated - if no one from the present can recall the rationale behind the past work, then critical elements can potentially be removed. Weick identifies the human story behind a decision being highly effective in transmitting the rationale behind what may appear to be a very dull or technical policy or procedure.

It is questionable whether all these features could or should be transferred to healthcare - a military type hierarchy would not be suitable. The scale and human nature of healthcare presents some significant challenges in this area. Nevertheless, concern about the rates of avoidable adverse events within healthcare change is driving change (Leape et al., 1991; Vincent et al., 2001), and elements such as establishing an organisational culture of safety are being applied to healthcare (See 1.3.11.2 The Scottish Patient Safety Programme, Page 65).

1.3.10 The Social Aspect of Change in Quality Improvement

As discussed previously, one of the key elements of QI is developing a culture within an organisation that is actively supportive of improvement (Radnor et al., 2006). Within organisations this culture will be informed by a multitude of social connections, both formal and informal, and so can be important instruments for influencing behaviours (Cunningham et al., 2012). Along with these internal social connections, clinicians will tend to have a number of connections to an external professional community (Goffee and Jones, 2007). These external social connections give them exposure to new knowledge and innovation, which they can feedback to their host organisations.

In this section, to understand how a new innovation may spread amongst individuals in an organisation Roger's model of "Diffusion of Innovations" will be briefly described (Rogers, 2003). Along with this, as behaviour is fundamentally what is being modified during QI, Michie *et al.*'s classification of behaviour

domains will be discussed as a method of identifying and enumerating barriers in this area (Michie et al., 2005). Finally, Deci *et al.*'s review of factors impacting motivation will be highlighted, as the individual must have motivation for engaging in a behaviour (Deci et al., 1999).

1.3.10.1 Diffusion of Innovations

“Diffusion is the process by which an innovation is communicated through certain channels over time among the members of a social system” (Rogers, 2003)

Rogers classified the diffusion of an innovation as a special type of communication; involving the transmission of new ideas (Rogers, 2003). To the receiver, the newness of these ideas imparts uncertainty into this communication. This uncertainty can be mediated by appropriate information, though human communication does not occur in a linear sender-receiver fashion. Rather humans are complex social creatures; this exchange of information has to be placed in the context of an existing social structure. If a new idea is truly to be successfully spread, not only will appropriate evidence be required, there will need to be a social change.

The most natural and effective communication occurs between individuals that are closely matched. That is, they are nearly identical for beliefs, social background, level of education, etc. The nature of communicating a new innovation introduces a discrepancy between the sender and receiver. The transmitter of the innovation will have a greater technical competence with the new innovation, introducing a communication barrier. To help overcome this, ideally the participants in diffusion communication should be as matched as possible in all respects other than the innovation. Otherwise effective communication will depend on at least one of the participants having a significant degree of empathy to overcome the communication barrier.

By its nature, diffusion of an innovation requires time. Every individual will respond to an innovation differently; though what is called – the innovation-decision process (See Table 6).

Table 6 Stages of the Innovation-Decision Process
Adapted from (Rogers, 2003)

Stage	Description
Knowledge	This is when the individual first gains an understanding of the new innovation.
Persuasion	At this point the individual forms an opinion about the innovation, either positive or negative. Peers are of particular importance at this stage, as they seek information from those they see as similar to them.
Decision	Here the individual engages in activities that lead to adoption or rejection of the innovation.
Implementation	This occurs when the individual puts the innovation to practice use.
Confirmation	Here the individual seeks reinforcement of the decision they previously reached. New information at this point may lead them to re-evaluate their previous decision.

Individuals will start this innovation-decision process at different points and progress through it at differing rates. How individuals respond to innovations can be classified into four different groupings (See Figure 7 and Table 7). From Figure 7 it can be seen these different adopter categories are normally distributed within a population.

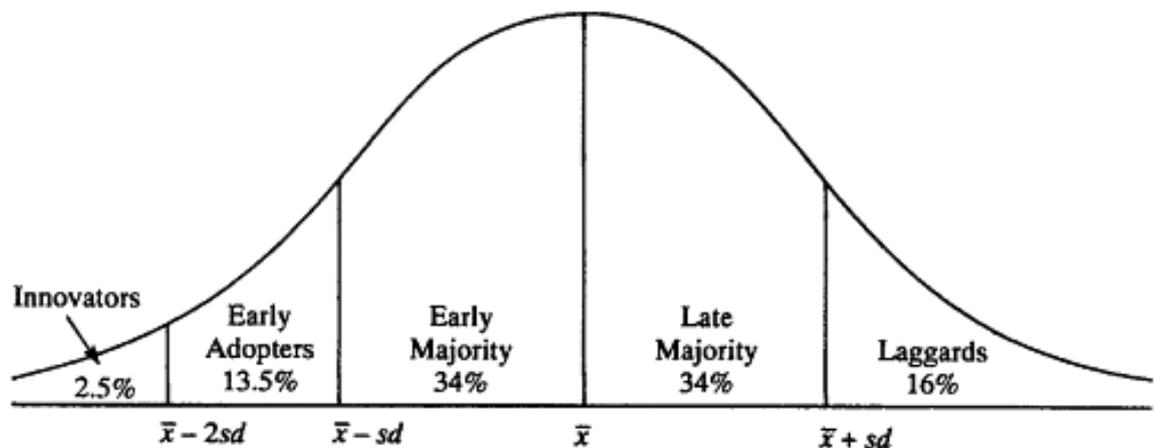


Figure 7 Distribution of Adopter Categories in a Population
From (Rogers, 2003)

Table 7 Features of the Different Adopter Categories
Adapted from (Rogers, 2003)

Term	Description
Innovators	Actively seek new ideas and become involved with them. Will have access to wide range of information and able to cope with high degree of uncertainty and potential setbacks. They may or may not be respected within their social structure, often they are seen as deviant to the social norms.
Early adopters	They tend to be seen as discerning users of new innovations and so less deviant than the innovators from the majority in the social structure. This group is likely to have a high number of opinion leaders within it, often being consulted by others for opinion/experiences of new innovations.
Early majority	This group are willing to take up new innovations, but are reluctant to do so until sufficient evidence is available from peers to negate their uncertainty. They rarely champion new innovations.
Late majority	This group tend to be sceptical and cautious of new innovations. They will wait until the weight is definitely in favour of the innovation before adopting.
Laggards	They are the most resistant to change, with their point of reference firmly being the past. They will perceive their resistance as rational; before they will commit resources to an innovation it must be completely certain that it will not fail.

Within an organisation a mix of individuals, of varying types, will be linked in a social structure that determines how they interact (See 1.3.10 The Social Aspect of Change, Page 57). In bureaucratic organisations, like the NHS, a formal hierarchy exists that means that higher ranked individuals can issue orders and expect those of lower rank to carry them out. However, external to this formal hierarchy, informal social networks will also exist between individuals within the organisation. Whilst these individuals could be distant within the formal hierarchy of the organisation, they are likely to be a group of like-minded individuals. An individual's place within these formal and informal social structures, along with the prevailing attitude within these groups regarding an innovation, significantly influences their likelihood of adopting the use of the innovation.

Opinion leaders will exist within all social structures. These will be individuals who are perceived by others as technically competent, socially accessible and conform to the social systems norms. If the nature of the social system is to be

innovative and cutting edge, the opinion leaders will be highly innovative. However, if the social system is resistant to change, the nature of the opinion leaders will also reflect this. Thus, opinion leaders exemplify the system's structure. Should an opinion leader deviate too far from the social norms or over use their leadership status, their ability to influence others is lost as followers become worn out and reject them.

The conclusion of diffusion is reaching a decision about whether or not to adopt the innovation. Rogers classified innovation decisions into four different types (See Table 8).

Table 8 Types of Innovation Decisions
Adapted from (Rogers, 2003)

Type	Description
Optional innovation decisions	The choice to adopt or reject an innovation is made by an individual independent of the other members of the system.
Collective innovation decisions	The choice to adopt or reject an innovation is made collectively by the members of the system.
Authority innovation decisions	The choice to adopt or reject an innovation is made by a few individuals in positions of authority within the system.
Contingent innovation decisions	The choice to adopt or reject an innovation is dependent on a previous decision. For example, an authority decision may allow the use of an innovation but not enforce it. The individual may then have an optional decision whether to use the innovation.

Generally authority decisions result in the fastest adoption of innovations within large organisations; though they can be circumvented during implementation. Optional decisions can usually be reached faster than collective decisions. Contingent decisions, due to the increased complexity, are often the slowest in encouraging diffusion of innovations.

A limitation of Roger's model is that it is based on a static innovation (Olson et al., 2010). In contrast the "innovation" within a QI project will tend to be dynamic and constantly evolving based on experience. This creates a situation where the innovation decision process is may not be linear; instead individuals may jump between different adopter categories based on the changing

innovation they are being presented with. Also Roger's model depicts an innovation as something complete that arrives externally; the reality of QI projects is that innovation is constantly derived from within the organisation and all the individuals within it- whether they be "laggards" or "early-adopters" (Essén and Lindblad, 2012). Regardless of these limitations, Roger's model is useful in describing the differing types of reaction a QI project may face, and remains widely used in QI literature (Scott et al., 2008).

1.3.10.2 Behaviour Domains

In an effort to make the psychology of behaviour change more accessible Michie *et al.* worked on developing a consensus model that identified a core group of domains that influence behaviour change (Michie et al., 2005). Attempting to compass every potential influence on behaviour would have been impossible. However, by following a consensus model this group managed to identify twelve major behaviour domains (See Appendix 1).

Overall the intention is that these behaviour domains aid in developing greater understanding of the underlying psychological influences at work when attempting to modify healthcare worker behaviour. Equally importantly, they give researchers a common terminology when describing the behaviour influences they encounter (Godin et al., 2008).

1.3.10.3 Intrinsic Motivation and External Rewards

Deci *et al.* reviewed the theory behind the interplay of intrinsic motivation and extrinsic rewards on the motivation of behaviours (Deci et al., 1999). Intrinsic motivation is the internal motivation of the individual to complete a task. Often this will be related to personal perception of competence and/or satisfaction. Extrinsic motivation is external reward for the completion of a behaviour. This can vary from verbal positive feedback to monetary rewards or bonuses.

In their review Deci *et al.* examined the theoretical underpinnings of how these concepts interact, specifically the premise that extrinsic rewards can erode intrinsic motivation. The theory behind this premise is that extrinsic rewards can impose a perception of control on the individual, eroding the intrinsic satisfaction of performing the behaviour. Also depending on how they are

awarded, these extrinsic rewards can impact the individual's perception of competence.

Evidence suggests that, whilst rewards are an effective method at modifying behaviour, how the individual perceives the reward significantly alters its effect on the intrinsic motivation. If the reward is seen as controlling, then it erodes the intrinsic motivation to perform the task. In contrast, if the reward is seen as a confirmation of competence, it enhances intrinsic motivation. Verbal positive feedback, a type of extrinsic reward, has been shown to enhance intrinsic motivation; though, if the positive feedback is phrased in an overly controlling manner, it too can decrease intrinsic motivation. This undermining effect is only relevant when the task itself is considered interesting by the individual. If the task is considered boring to begin with, the individual has little inherent intrinsic motivation for any extrinsic reward to undermine.

Therefore, an organisation should be very cautious about employing rewards as a method to control behaviour. They may prove effective in the short term, but are likely to erode the individual's self-motivation and self-regulation.

1.3.11 *Scottish Experience with Healthcare Quality Improvement*

There has been a long history of government reports into the future direction of the NHS in Scotland. In the recent past these have begun to include quality improvement methodologies as central themes, beginning with the 2005 report "Building a Health Service Fit for the Future" (Kerr report). This introduced the need for improved clinical safety, and a movement to more patient centred care, multidisciplinary and anticipatory care, and pressed the need for improved information technology to support clinical care in NHS policy (The Scottish Executive, 2005).

This was followed up by the 2007 report "Better Health, Better Care", which further reinforced quality improvement methodologies such as; making patient centred care as an NHS priority, refining the national Health improvement, Efficiency, Access and Treatment (HEAT) targets, expanding managed clinical networks, support for the Scottish Patient Safety Alliance to improve patient

safety, and further development of benchmarking between NHS boards. It was also the “Better Health, Better Care” report that introduced the Childsmile demonstration project as an attempt to address inequalities in levels of dental caries in children (The Scottish Government, 2007).

1.3.11.1 Quality Strategy

In May 2010 the Scottish Government published The Healthcare Quality Strategy for NHS Scotland (The Scottish Government, 2010), which formalised the quality priorities for NHS Scotland as:

- Caring and compassionate staff and services
- Clear communication and explanation about conditions and treatment
- Effective collaboration between clinicians, patients and others
- A clean and safe care environment
- Continuity of care
- Clinical excellence

These quality priorities are reinforced by three “quality ambitions”:

1. Mutually beneficial partnerships between patients, their families and those delivering healthcare services which respect individual needs and values and which demonstrate compassion, continuity, clear communication and shared decision-making.
2. There will be no avoidable injury or harm to people from the healthcare they receive and an appropriate, clean and safe environment will be provided for the delivery of healthcare services at all times.
3. The most appropriate treatments, interventions, support and services will be provided at the right time to everyone who will benefit and wasteful or harmful variation will be eradicated.

These quality ambitions are closely related to the dimensions of quality improvement as laid out by the Institute of Medicine (See 1.3.1.1 A Definition of Quality Improvement, Page 31). However, the one domain of “Equitable” healthcare appears excluded. As discussed in relation to health promotion, equitable distribution of healthcare resources within a publicly funded system is a challenging ethical issue (See 1.2.4.6 Ethical Aspects of Health Promotion, Page 24). Therefore, a lack of an accepted common definition of “equitable” healthcare may explain why this domain appears to be excluded.

Finally the Quality Strategy introduced a suite of 12 potential national quality outcome measures, that will be used to assess the performance of NHS Scotland in relation to quality (See Appendix 3).

1.3.11.2 The Scottish Patient Safety Programme

In January 2008 the Scottish Patient Safety Programme (SPSP) was established to run until December 2012 (Haraden and Leitch, 2011). It builds on a long held culture of quality improvement within the Scottish health service. Examples of this quality improvement culture include; the Scottish Intercollegiate Guideline Network (SIGN) which is a leading organisation in the production of evidence based guidelines for clinical care (See 1.2.3 Clinical Guidelines, Page 18) and the Scottish Audit of Surgical Mortality where every inpatient death under the care of a surgical specialty is audited nationally to identify if any avoidable events are contributing to patient deaths (The SASM Board, 2010). Much of the impetus for establishing the SPSP came from work in Ninewells hospital in Dundee. Here they found that by using the Global Trigger Tool, developed by the Institute for Healthcare Improvement as a systematic method of identifying causes of patient harm; they reduced overall patient harm by over 60%.

The five year goals of the SPSP are to reduce inpatient mortality for any cause by 15% and to reduce hospital adverse events, as measured by the Global Trigger Tool, by 30%. To achieve these goals the initial introduction of the SPSP involved; stressing the importance of safety at health board meetings, the introduction of safety walkarounds and the inclusion of a safety element in all health board communications. The safety walkarounds involved the local hospital leadership physically walking all patient care areas. They were

structured as so to provide an ordered method for front-line staff to communicate concerns relating to patient safety, the information gain was to be analysed, effective actions then identified and a system put in place to ensure they were carried out. The SPSP team also ensured that they liaised with other programmes working within NHS Scotland to improve patient care, to ensure that in any situations of overlap a common approach was taken.

Part of the challenge of the SPSP was to develop the improvement skills within the NHS Scotland workforce and to facilitate the required improvements thereby achieving the goals of the programme. To develop these skills a Scottish clinical improvement faculty was established, with formal training provided to a range of NHS staff on improvement methodologies. The core improvement methodology used by the SPSP is the PDSA model for improvement (See 1.3.3 The Plan-Do-Study-Act (PDSA) Cycle, Page 40). To ensure that improvement knowledge is shared across the NHS in Scotland biannual national meetings were organised. These allowed improvement teams from different parts of the country to share experiences and learn from each other. In addition, monthly calls with teams were carried out to discuss progress and any barriers.

Significant effort was required to develop data measurement systems that provided information useful to individual clinicians/wards/departments on how they could improve their performance. It found, whilst large amounts of data were reported by different elements of the NHS in Scotland it was mostly technical and aggregate in nature and used primarily to monitor the performance of the NHS at a national or regional level. To develop data that was timely and useful to individuals the SPSP developed their own electronic reporting system. However, to minimise the burden of data entry they ensured that any useful data already being collected was automatically incorporated. The data collection process was integrated into existing hospital data systems, and effective sampling strategies were employed to minimise the additional workload. By the 2010 halfway point, the SPSP was well integrated across the acute hospital service in NHS Scotland. The results by meeting the programme goals at this midpoint show that the national standardized mortality rate fell by 5%; along with falls in rates in both *Clostridium difficile* and central-line infections.

At present the SPSP is focused on the acute hospital setting. This is a result of this healthcare setting carrying the greatest immediate and obvious risks (World Health Organization, 2004). Whilst risk does exist in primary medical care, the understanding and management of this lags the acute setting (Wilson et al., 2001). As of writing, no literature directly related to dental care and the patient safety agenda could be identified.

1.3.11.3 HEAT Targets

HEAT targets were introduced by the Scottish Government as nationally agreed targets for NHS Scotland in 2006 (“An introduction to HEAT Targets,” n.d.). Since their introduction there have been two HEAT targets related to oral health. In 2008 the first oral health target was introduced - 80% of all three to five year old children to be registered with an NHS dentist by 2010/11. This target was achieved. In 2010 a second oral health target established - 60% of 3 and 4 year olds in each SIMD quintile to have fluoride varnishing twice a year by March 2014 (Scottish Government, 2003). This is the first oral health HEAT target that relates directly to clinical practice, rather than service capacity. An important element in achieving the 60% goal will be the delivery of the Childsmile Programme within primary care (See 1.2.5.2 Childsmile, Page 28). As part of this team, general dental practices will have an important role to play and this was recognised by the creation of a fee for application for fluoride varnish for GDPs working under the NHS.

1.4 Caries Risk and Prevention

Over the course of the 20th century in the developed world dental caries has moved from being a ubiquitous disease to one that is generally concentrated in a subset of the population (Macpherson et al., 2010a). Whilst it is debated whether a universal or targeted approach to prevention is the most valid (See 1.2.4.2 Targeted Approach, Page 20 and 1.2.4.3 Universal Approach, Page 21), if the subset of the population most at risk of developing caries in the future could be accurately identified, resources could be effectively and efficiently directed towards them. This means that any caries risk assessment (CRA) must be followed up with appropriate preventive care (Messer, 2000).

Determining an individual's future caries risk is difficult, due to its complex and multi-factorial aetiology (Featherstone, 2004). A number of modifying factors, both protective and detrimental, have been identified in relation to caries risk (Reich et al., 1999; Zero et al., 2001). These modifying factors can be classified into the following categories; clinical evidence, diet, social history, fluoride, oral hygiene, saliva and medical history (SIGN, 2005, 2000a). Assessment of an individual's overall caries status requires the weighing up of these modifying factors to determine an overall risk (Evans et al., 2010). Whilst a number of differing models for determining this overall risk have been proposed, the evidence for the validity for these various systems is currently limited (Tellez et al., 2012). A review by the National Institute for Health and Clinical Excellence concluded that the clinical judgement of the dentist in weighing up these factors is as good or better, than any other method (National Institute for Health and Clinical Excellence, 2004).

It is accepted that if an illness can be avoided by prevention, then this is more effective than treatment. This is especially true in relation to dental caries, with no currently available restorative technique able to match the longevity of healthy dental hard tissues. Health policy within Scotland is shifting to reflect this new paradigm. From a NHS that was set up to be reactive, hospital-centred, doctor-dependent and patient-passive; to a health service designed to be proactive, integrated, team-based, preventive and where the patient is a central partner in their care (The Scottish Government, 2010, 2007). In the field of oral health care, this means developing a system of care, which moves dentistry away from the cycle of 'drilling, filling, root treating and extracting teeth'. It is argued that it is counterproductive to spend continually larger proportions of national income on the treatment of disease which does not necessarily improve the nation's health. However, as the range of potential preventive therapies increases, increasingly detailed cost-effectiveness analysis will be required for such treatments (National Institute for Health and Clinical Excellence, 2008).

1.4.1 Clinical evidence

1.4.1.1 Clinical Risk Factors

Research conducted by Milsom et al. in primary dental care found that being caries free had a significant impact on whether a child subsequently developed caries (Milsom et al., 2008). In the group that was caries free at recruitment they found that 1 in 42 would develop a new carious lesion each year. This compares with the group with caries at recruitment where they found that 1 in 7 would go on to develop a new carious lesion each year. This equates to a 5-6 times difference in the risk of developing new carious lesions between the two groups. However, past caries experience cannot be used as a risk predictor in very young child, where their primary teeth have just erupted, or may not yet have any teeth. In this situation white spot lesions, indicators of demineralisation of the tooth substance, the first stage in the development of a carious lesion, should be carefully looked for in the dentition of a young child in this situation instead of past caries experience (American Academy of Pediatrics, 2008).

Batchelor and Sheiham analysed data of 20,000 5 to 16 year old children from the National Preventive Dentistry Demonstration Programme in the United States (Batchelor and Sheiham, 2004). This allowed them to identify the sites within the mouth most susceptible to developing caries in the permanent dentition. In order of susceptibility these were:

1. Occlusal surfaces of first molars and buccal pits of lower first molars.
2. Occlusal surfaces of second molars, buccal surfaces of lower second molars and occlusal surfaces of all second premolars.
3. Occlusal surfaces of first premolars, palatal surfaces of upper lateral incisors, approximal surfaces of first molars, lingual surfaces of lower first molars, buccal surfaces of upper first molars and palatal surfaces of upper second molars.
4. All approximal surfaces of second premolars, all approximal surfaces of upper first premolars, mesial and lingual surfaces of lower second molars,

distal and buccal surfaces of upper second molars, approximal surfaces of upper central incisors, approximal surfaces of upper and lower lateral incisors, distal approximal surfaces of upper canines and approximal surfaces of second molars

5. All surfaces of lower canines, buccal/mesial/labial aspects of upper canines, all smooth and approximal surfaces of lower first premolars, smooth surfaces of lower central incisors and approximal surfaces of lateral incisors.

Along with vulnerability to dental caries at particular sites, the enamel of newly erupted teeth is particularly at risk (Garcia-Godoy and Hicks, 2008). This is due to the high prevalence of carbonate in newly erupted enamel, which makes the enamel more acid soluble. Conversely, newly erupted teeth are also permeable to the fluids of the oral environment. This allows ion exchange to occur, which importantly for caries resistance, allows the exchange of hydroxide groups for fluoride ions, eventually making the enamel more acid resistant. The process of the enamel losing this permeability and becoming less acid soluble can take up to 5 years and is termed post-eruptive maturation.

1.4.1.2 Clinical Preventive Interventions

An important element of preventing the development of significant dental caries, is early detection and intervention in the early stages of the disease (Evans et al., 2010). Recall intervals have a significant impact on clinician workloads and healthcare costs, whilst potentially influencing patient outcomes. Many chronic conditions requiring longitudinal care have been found to have a wide variation between practitioner's protocols for recall intervals. This suggests that there is a lack of good evidence in this area. The ideal recall interval would optimally balance the costs of more frequent recalls, the majority of which may potentially be superfluous, against the cost less of frequent recalls, which could potentially lead to disease being detected at a later and more expensive to treat stage. Historically the 6 month recall interval has been advocated in the dental profession. However, this time frame has long been controversial as there is no evidence behind its rationale (Sheiham, 1977). A 2007 Cochrane review on the topic of recall intervals for dental check-ups

found only one study eligible for inclusion in the review. This was judged to have a high risk of bias and the review was therefore unable to draw any conclusions on the topic of recall intervals (Beirne et al., 2007). In an attempt to address this topic, the University of Dundee is leading a major clinical trial comparing a fixed 6-month, a risk-based and a fixed 24-month check-up interval (NIHR HTA, 2013).

Along with regular clinical examination, the appropriate use of dental radiographs significantly improves the detection of carious lesions (Kidd and Pitts, 1990). However all radiographs, even low-dose intraoral dental radiographs, carry a potential degree of risk from exposure to ionising radiation and therefore clinicians should consistently look to minimise the exposure to the patient whilst maximising the information gained from a radiographic exposure. EAPD guidelines for dental radiography for children recommend a combination of baseline radiographic examinations at potentially critical times for the detection of caries in all children, along with a risk based approach to the interval between radiographic examinations (See Table 9) (Espelid et al., 2003).

Table 9 EAPD Guidelines for Dental Radiography in Children

Baseline radiographic examination	Interval to next radiographic examination	
	Low risk	High risk
At age		
5 years	3 years	1 year
8 or 9 years	3-4 years	1 year
12 to 16 years	2 years	1 year
16 years	3 years	1 year

Fissure sealants involve placing a bonded resin over the fissures of molars and/or premolar teeth, where are susceptible site for caries development (See 1.4.1.1 Clinical Risk Factors, Page 69). A Cochrane review investigating the effectiveness of fissure sealants on preventing occlusal caries found them to be

effective at preventing caries in the occlusal surfaces of permanent molars (Ahovuo-Saloranta et al., 2008). In the meta-analysis when resin-based sealants were compared to a control without a sealant, they found a 87% reduction in risk (pooled risk ratio of 0.13, 95% CI 0.09 to 0.20) at 12 months, 78% reduction in risk (pooled risk ratio of 0.22, 95% CI 0.15 to 0.34) at 24 months, 70% reduction in risk (pooled risk ratio of 0.30, 95% CI 0.22 to 0.40) at 36 months, and 60% reduction in risk (pooled risk ratio of 0.40, 95% CI 0.31 to 0.51) at 48-54 months.

There is only limited literature on the use of sealant on primary molars. A recent systematic review, did support their use on primary molars, with the caveat that the evidence was more limited than for the use of sealants in the permanent dentition (Azarpazhooh and Main, 2008). The review also reported that there was some evidence that placement of sealant material over arrested or incipient carious lesions does not increase the risk of further development of caries under the sealant. The recommendations from their review include:

- Sealants should be placed on all permanent molar teeth without cavitation.
- Sealants should not be placed on partially erupted teeth, or teeth with cavitated lesions or caries into dentine.
- Sealants should be placed on the primary molars of children judged to be at high risk for caries.
- Sealants should be placed on first and second permanent molars within 4 years after eruption.
- Resin-based sealants should be preferred to Glass Ionomer Cements.
- Sealants should form part of a comprehensive preventive programme based on assessment of the individual patients caries risk status.

1.4.2 Diet

1.4.2.1 Dietary Risk Factors

Frequent consumption of fermentable carbohydrates (See Table 10) can be a powerful risk factor, in populations with poor oral hygiene and lack of fluoride exposure (Axelsson, 2000). However, in populations with good oral hygiene and the protective influences of fluoride, this predictive relationship breaks down. As mentioned previously (See 1.2.4.5 Social Determinants of Health, Page 23), the development of caries is multifactorial, and if bacteria are effectively eliminated, then the frequent consumption of fermentable carbohydrates is unlikely to lead to caries development.

Table 10 Fermentable Carbohydrates

Monosaccharides	
• Glucose	• Fructose
Disaccharides	
• Sucrose	• Maltose
• Lactose	
Polysaccharides	
• Glucan	• Mutan
• Fructan	• Starch

All of the above fermentable carbohydrates can be metabolised by plaque bacteria to acids. However, their respective rates of metabolism vary. It is the monosaccharides and disaccharides that are rapidly metabolised by the plaque covered tooth, inducing the production of acid (mainly lactic acid) and a subsequent fall in pH. This lowers the pH of the dental plaque from a resting pH 7.0, to a pH less than 5.0, which importantly is below the critical pH of 5.5 for enamel demineralisation. When the pH falls below the critical pH calcium and phosphate is lost from the subsurface enamel.

Following the cariogenic challenge the pH rises again above the critical pH and the increased hydrogen ion concentration of the low pH is no longer driving the loss of calcium and phosphate from the enamel. A diffusion gradient now exists between the enamel and saliva, which is supersaturated with regards to calcium and phosphate. This gradient passively transports calcium and phosphate ions back into the enamel, allowing remineralisation of the enamel. These periods of demineralisation and remineralisation are a dynamic cycle, depending on the

frequency of cariogenic challenge. If adequate periods of remineralisation exist between those of demineralisation then the integrity of the enamel surface can be maintained. If not, the demineralisation process will continue until breakdown of the enamel surface occurs and cavitation becomes evident clinically (Garcia-Godoy and Hicks, 2008).

Sucrose is particularly highlighted as a cariogenic sugar, as it is the substrate for the formation of both extracellular polysaccharides and insoluble matrix polysaccharides in the plaque. Consumption of sucrose containing sweets more than once a week at age of 2 years was found to be related to the risk of developing caries in the first permanent molars (Ollila and Larmas, 2007). Whilst lactose is one of the least cariogenic sugars, it can also lead to the development of caries (Seow, 1998).

The polysaccharides are generally molecularly too large to diffuse into the plaque. However, cooking processes and the action of salivary amylase can breakdown the long chain molecules into smaller molecules that are then available for bacterial metabolism. Therefore, the prolonged retention of starchy foods in the mouth, in situations of poor oral hygiene, can lead to caries development.

In a recent review on the topic of sugars and caries, no evidence could be found to support a relationship between quantity of sugar and caries (Anderson et al., 2009). However, the review did find evidence a significant relationship between frequency of use of sugar and caries. Given the need to delivery consistent health promotion messages (See 1.2.4.4 Common Risk Factor Approach, page 22), the lack of evidence of a link between quantity of sugar and caries should not prevent oral health professionals from advocating a reduction in sugar consumption, as this will have benefit in other areas such as obesity.

1.4.2.2 Dietary Preventive Interventions

As discussed above, the presence of fermentable carbohydrate in the oral cavity is a key component in the development of dental caries. Carbohydrate is an essential dietary component and cannot be eliminated from the diet, so advice should centre on risk reduction. With regard to reducing the development

dental caries, advice should centre on: reducing the frequency of consumption; avoiding the most cariogenic sugars; avoiding sticky food that inhibit self-cleansing of the teeth; and avoiding consumption of fermentable carbohydrate immediately prior to periods when self-cleansing/saliva rates are reduced, primarily immediately before sleep.

This dietary advice should be linked into a common risk factor approach to disease prevention (See 1.2.4.4 Common Risk Factor Approach, Page 22), as diet is a significant influence on the development of many health conditions. Of particular concern is the increasing prevalence of childhood obesity with associated health problems including cardiovascular, endocrine, and mental health issues. A major element of preventing childhood obesity is promoting healthy eating behaviours. Therefore, a common risk factor for both obesity and dental caries is the consumption of juice and sugar sweetened beverages (American Academy of Pediatrics, 2008). It must also be noted that diet is immersed in the wider socioeconomic factors that influence health (See 1.4.3 Social), as ones socioeconomic status will influence what food choices are available and/or affordable.

A recent Cochrane review has been undertaken on the topic of dietary interventions in the dental setting (Harris et al., 2012). For inclusion in the review studies must have involved one-to-one intervention with either a dentist or dental care professional. Interventions included; brief advice, skills training, giving of self-help materials, counselling, lifestyle strategies, or any combination of these. Five studies were found to meet the criteria. Of these, two were concerned with diet advice in relation to general health, specifically decreasing alcohol consumption and increasing fruit and vegetable intake. Of the remaining three, two were multi-intervention studies with the dietary intervention forming one aspect of a wider prevention programme and the one remaining study specifically looked at the prevention of dental caries through the restriction of sugar. Four out of the five studies did demonstrate success in modifying dietary behaviour. However, the authors highlighted the lack of evidence in relation to this topic being of concern, particularly given the importance of the desired outcome and frequency of which dietary advice is undertaken in relation to dental health.

1.4.3 Social

1.4.3.1 Social Risk Factors

Epidemiological studies in Scotland, have consistently shown that it is the children who are living in the most socioeconomically deprived areas of the country that have the most dental caries (Macpherson et al., 2010a; Merrett et al., 2010). In tandem with this, children born into families of low socioeconomic status are more likely to begin life in poor general health with a higher prevalence of foetal and birth complications in this group. The effect of this poor natal health can have a persistent effect into adulthood (Conley and Bennett, 2001; Hack et al., 2002).

A longitudinal study by Poulton *et al.* followed 980 individuals at regular intervals from the age of 3 to 26 years (Poulton et al., 2002). They found that; even after controlling for increased prevalence of poor natal health in the low socioeconomic children and for the impact of socioeconomic status at 26 years of age on health; the association of childhood socioeconomic status and adult health remained significant. The dental health measures used in the study, plaque levels, periodontal health, DMFT, all showed a relationship with childhood socioeconomic status. As childhood socioeconomic status increased, adult dental health improved, regardless of eventual adult socioeconomic status at age 26.

As well as socioeconomic deprivation, several other social background factors; maternal education, ethnic minority status and passive smoking have all been reported as caries risk factors (Aligne et al., 2003; Verrips et al., 1993; Williams et al., 2000). The difficulty with social risk factors is their complex relationships; one social factor might simply be a marker of some other true risk factor, like parental smoking being an indicator of poor parental attitudes to health generally. These interlinked relationships mean that socioeconomic factors have yet to be distilled down their individual impact on both oral and general health.

It has been reported that self-esteem is strongly correlated with an individual's oral health behaviour (Källestal et al., 2000; McGrath and Bedi, 2003). Ozolins

and Stenström's study of Swedish adolescents reported that those with good self-esteem had greater self-belief in their ability to influence their health (Ozolins and Stenström, 2003). Whilst those who felt that control of their own health was out with their control, had lower overall self-esteem. These issues of self-esteem and self-control over health are highly important during the formative years of adolescence. Broadbent *et al.* showed that beliefs and attitudes formed during this period tend to persist into adulthood (Broadbent *et al.*, 2006).

Adolescence is also a key stage in dental development and a particular at risk stage for the development of caries. Over this period the final permanent dentition is established, but is yet to undergo post eruptive maturation, the stage where the enamel becomes more resistant to dissolution due to exposure to the oral environment. Adolescence is also the stage where independence from parental control is established and this particularly applies to diet and oral hygiene; so frequency of consumption of cariogenic food and drink is likely to increase, whilst oral hygiene habits can often become worse.

Therefore, it is important that the adolescent group is engaged in an appropriate fashion by the dental team, ensuring they reach adulthood with as limited caries experience as possible. In interviewing a group of high caries risk adolescents in Sweden, Hattne *et al.* identified 7 key themes: knowledge, activities, positive feelings, impassiveness, negative feelings, appearance and function (Hattne *et al.*, 2007). Overall respondents often had knowledge of the determinants of good oral health, however when it came to application of this knowledge there was often conflicted emotions— particularly ambivalence. They often reported that they had not initially been made adequately aware of their risk of developing caries; this leading to feelings of frustration later. With regards to oral hygiene, none of the respondents placed an emphasis on the quality of toothbrushing, instead they purely discussed the frequency of brushing episodes. Often they would report that past attempts to improve oral hygiene had not had the desired result, leading to resignation that their oral health was something beyond their control. This resignation to a perceived inevitability of poor oral health, could negatively impact on their overall self-esteem.

1.4.3.2 Social Preventive Interventions

Influencing an individual's social determinants is a key element of public health promotion (See 1.2.4.5 Social Determinants of Health, Page 23). However, the ability to directly influence these social influences is beyond the scope of preventive interventions delivered by the clinician. Importantly, an awareness of their potential impact on other preventive interventions, i.e. dietary counselling (See 1.4.2.2 Dietary Preventive Interventions, Page 74), can aid the clinician in tailoring preventive advice to be more effective for the individual patient.

1.4.4 Fluoride

1.4.4.1 Fluoride Risk Factors

In terms of impacting the risk of developing dental caries, not using fluoride does not necessarily lead to the development of dental caries. Nonetheless, as fluoride is a powerful intervention for the prevention of dental caries, not using it would place the individual at an increased risk relative to an identical individual who did. Consequently, in constructing a model for assessing an individual's caries risk an assessment of their use of appropriate fluoride interventions is useful.

1.4.4.2 Fluoride Preventive Interventions

The initial evidence of the caries preventive effect of fluoride came from the epidemiological observation of populations exposed to naturally fluoridated water supplies (Featherstone, 1999). In these communities, a significantly lower rate of dental caries was observed. It was noted that a proportion of individuals in these communities exhibited a noticeable marking of the teeth, later termed "fluorosis", which must be due to the action of fluoride whilst the teeth are forming. From these observations a theory advocating that significant reductions in caries could be achieved by the systemic consumption of an optimal dose of fluoride. Successful water fluoridation trials in the 1940s and 1950s reinforced this theory. However, more recently there has been a move away from a systemic action for fluoride, to a model which proposes that the caries preventive effect of fluoride is topical in nature (Adair, 2006).

The benefit of fluoride for caries prevention is well established. Community water fluoridation was hailed as one of the ten most important public health advances of the 20th century (CDC, 1999). However, its success has been dependent on public water supplies and the political will to fluoridate them. Other fluoride delivery vehicles, such as mouthrinses, gels, and toothpastes have all been found to be effective in the prevention of dental caries. However, these interventions are highly dependent on the compliance of the patient for their effectiveness (Milgrom et al., 2009). The main preventive effect of fluoride appears to come from its ability to integrate with tooth enamel to form fluorhydroxyapatite, rendering the enamel more resistant to acid dissolution. In addition fluoride is strongly antimicrobial, giving it additional anticaries activity (Breaker, 2012).

Fluoride toothpaste has been commercially available since the 1950s and is considered to have had the most significant impact of any preventive intervention on the decline of dental caries (Bratthall et al., 1996). A meta-analysis by Marinho *et al.* of the use of fluoride toothpaste in children and adolescents found that the use of a fluoride toothpaste gave a pooled preventive fraction for DMFS of 24% (95% confidence interval 21% to 28%; $p < 0.0001$) (Marinho et al., 2003b). In this meta-analysis, the caries preventive effect of fluoride toothpaste increased with:

- Higher baseline caries levels.
- High fluoride concentration in the toothpaste.
- Greater frequency of toothpaste use.
- Supervised toothbrushing with the fluoride toothpaste.

Duckworth *et al.* found that plaque fluoride concentrations increase with an increasing concentration of fluoride within toothpaste. They also found that plaque fluoride concentrations tended to increase with increased frequency of brushing. In contrast no relationship was found between the amount of toothpaste used during brushing and plaque fluoride concentrations. This suggests that it is the fluoride concentration of the toothpaste and the

frequency of its use that are the important elements in maximising the caries preventive effect of fluoride toothpaste (Duckworth et al., 1989).

In a study of Scottish 10-11 year olds reported by Chestnutt *et al.* they found a significant correlation ($p < 0.001$) between self-reported brushing frequency and 3-year DMFS increment (Chestnutt et al., 1998). In those reporting brushing less than once daily the 3-year DMFS increment was 8.9, compared to those who reported brushing once daily the DMFS increment was 6.6 and with those who reported brushing more than once daily where the DMFS increment was 5.5. They also found a significant correlation ($p < 0.05$) between the 3 year caries increment between those who self-reported post-brushing rinsing (3 year DMFS increment = 6.84) and those who did not rinse post-brushing (3 year DMFS increment = 5.84).

Recently, interest has focused on the use of “high” concentration fluoride toothpastes. These products available at either 2,800 or 5,000 ppm F^- and are based on the rationale that it is concentration of fluoride that influences caries prevention. Currently the 2,800 ppm F^- toothpaste is licenced for the use of children over the age of 10 years and the 5,000 ppm F^- toothpaste for those over the age of 16 years. Work by Nordström and Birkhed has found that the high concentration, 5,000 ppm F^- , toothpaste can be of particular use in high caries risk adolescents (Nordström and Birkhed, 2010). When compared to a 1,450 ppm F^- control over 2 years the rate of caries progression was significantly less in the high fluoride group. They also found that for teenagers who reported less than twice daily brushing, those using the high fluoride paste developed significantly less new carious lesions.

Fluoride varnishes, generally used at a concentration of 22,600ppm F^- , are important vehicles for the delivery of fluoride as they are easy-to-use, safe, cheap and particularly effective for use in preschool children; one of the most difficult groups to reach with other fluoride vehicles. Marinho *et al.* performed a meta-analysis of 9 studies involving 2,709 children. They found that for DMFT the pooled preventive fraction was 46% (95% confidence interval, 30% to 60%; $P < 0.0001$), whilst for dmft the pooled preventive fraction was 33% (95% confidence interval, 19% to 48%; $P < 0.0001$) (Marinho et al., 2002). Current UK guidelines recommend that all children have fluoride varnish applied at least twice a year,

and that high caries risk children should have it applied four times a year (Evans et al., 2010). As mentioned previously twice yearly application of fluoride varnish forms a key component of the Childsmile project (See 1.2.5.2 Childsmile, Page 28).

A meta-analysis of 34 studies pooling 14,600 children by Marinho *et al.* found that supervised daily rinsing with a fluoride mouthrinse had a DMFS pooled preventive fraction of 26% (95% confidence interval, 23% to 30%; $P < 0.0001$) (Marinho et al., 2003a). They found that the two main rinsing schedules were either daily rinsing with a 230ppm F^- rinse, or weekly/fortnightly rinsing with a 900 ppm F^- . Currently in the UK, daily use of fluoride mouthrinses at 0.05% (225 ppm F^-) is recommended for high caries risk children over the age of 6 years; younger children are contraindicated primarily due to the risk of ingestion (Evans et al., 2010). Weekly supervised rinsing with the 900 ppm F^- rinse at school was a popular school based oral health intervention in Scandinavian countries and the USA in the 1970s and 80s. However, these programmes fell out of fashion, as the distribution of dental caries became increasingly concentrated in a high caries risk group; leading to the cost-benefit of these programmes becoming unsustainable (Disney et al., 1990).

Fluoride supplements, delivered as either tablets or drops, were initially proposed as means of delivering fluoride to children not living in areas with water fluoridation (“British Society of Paediatric Dentistry,” 1996). It has become increasingly accepted that the main cariostatic effect of fluoride is topical in nature, rather than systemic. This has led to recent guidance in the UK moving away from recommending the use of fluoride tablets or drops, to other forms of additional fluoride, like high strength toothpastes or fluoride varnish. However, at present fluoride tablets and drops still remain available for UK dentists to prescribe for caries prevention.

Silver Diamine Fluoride is a material that has been available in some regions of the world, particularly Asia, for several years. It commonly used at a concentration of 38% (44,800 ppm F^-), and has been reported to be highly effective in arresting active carious lesions. The potential drawback of this material is it also stains these carious lesions a dark black colour. Whilst this material has not yet been brought to the UK, research carried out in other parts

of the world have found it too be highly effective at arresting caries after a one off application (Chu and Lo, 2008; Chu et al., 2002; Llodra et al., 2005; Yee et al., 2009).

The use of an intraoral slow-release fluoride device has been proposed as a method to constantly supply an optimal dose of topical fluoride to the oral environment without reliance on patient compliance (Toumba and Curzon, 2005). As discussed above the main caries preventive action of fluoride is topical and as so by maintaining a low but constant level of fluoride in the oral cavity you can shift the environment in favour of re-mineralisation. Constant slow-release devices are used to deliver medication for other medical treatments, for example birth control, treatment of glaucoma, and prevention of motion sickness.

The slow-release devices developed are bonded to the surface of the dentition, usually the buccal surface of upper first permanent molar and have been shown to deliver an increased salivary fluoride level for up to two years after attachment. Importantly these devices, once attached and as long as they do not debond, remain in situ delivering this background dose of fluoride without the need for patient intervention (Toumba et al., 2009). Featherstone reported that a constant background salivary fluoride level of 0.1ppm F⁻ would be sufficient to prevent the majority of dental caries progression, which should be readily achievable with the use of a slow-release device (Featherstone, 2006)

1.4.5 Oral hygiene

1.4.5.1 Oral Hygiene Risk Factors

Dental plaque is a complex ecosystem, consisting of a diverse environment of bacteria suspended in a polysaccharide matrix. This polysaccharide matrix is generated by oral bacteria, particularly *mutans streptococci*. This matrix allows the bacteria to adhere to the tooth, protect the bacteria from anti-bacterial enzymes in the saliva and acts as store of nutrients for later metabolism. As the dental plaque matures the bacteria ecosystem becomes more anaerobic and acidogenic. However, the development of a mature dental plaque takes time. The effective removal of plaque can have a significant impact on the

development of dental caries because by removing the plaque from the teeth the bacterial environment is disrupted.

The most commonly performed oral hygiene technique is twice daily toothbrushing with a fluoride toothpaste, which is effective at disrupting the dental plaque along with delivering the preventive effects of topical fluoride (Nguyen et al., 2008). Lack of daily toothbrushing at the age of 2 years was found to be related to the risk of developing caries in the first permanent molars (Ollila and Larmas, 2007). Whilst poor oral hygiene is associated with poor health practices generally (Axelsson, 2000). Due to the multifactorial nature of dental caries, there needs to be a combination of factors, like frequent consumption of cariogenic foods along with poor oral hygiene, before caries will develop.

1.4.5.2 Oral Hygiene Preventive Interventions

Twice daily toothbrushing with fluoride toothpaste forms the corner stone of modern caries preventions. It is a preventive intervention that is effective, cheap and ubiquitously accepted as part of routine personal hygiene within society. In terms of ideal routine, several parameters have been examined by researchers. Two studies involving Scottish children have shown that; those who brush less than twice-daily consistently have a higher caries increment, whilst those who rinse with water following brushing develop more recurrent carious lesions (Chesters et al., 1992; Chestnutt et al., 1995). A number of studies have shown supervised toothbrushing programmes for young children, generally based around school, are effective at reducing the caries increment (Curnow et al., 2002; Jackson et al., 2005).

The evidence for the effectiveness of dental health education is inconclusive (Kay and Locker, 1996). Given that the development of dental caries is a long term process, it is the individual's own habits that greatly influence the development of the disease – particularly in relation to diet and oral hygiene. The literature does suggest that knowledge about positive oral hygiene practices can effectively be transmitted to patients, but the translation of this knowledge into long term positive behaviours that proves challenging (Brukiene and Aleksejūniene, 2009). However, professional toothbrushing instruction must

play a fundamental part of any caries preventive regime, if any attempt is to made to modify these behaviours (Evans et al., 2010).

1.4.6 Saliva

1.4.6.1 Salivary Risk Factors

Saliva is complex substances whose composition varies greatly both between individuals and within the same individual at differing times, and therefore has a significant impact on the oral environment. A large variety of different analytes have been found, including inorganic components such as Sodium, Potassium and Phosphate, and organic components such as proteins, enzymes and amino acids (Ferguson, 1999).

The relative ability of an individual's saliva to buffer for the action of acid is considered one of the best indicators of individual caries susceptibility. Individuals with saliva with a high buffering capacity are often able to resist caries, even when they consume a highly cariogenic diet (Messer, 2000). Abnormal saliva can result from a variety of causes, for example xerostomia induced by anticholinergics drugs, tricyclic antidepressants drugs, diabetes mellitus, ectodermal dysplasia, or following radiotherapy (Foster and Fitzgerald, 2005).

1.4.6.2 Salivary Preventive Interventions

At present there are no interventions available to modulate the composition of saliva. Clinicians must be aware of the potential for reduced salivary flow, particularly in medically compromised patients, and can prescribe exogenous lubricants if required. Commercial tests do exist to measure the buffering capacity of saliva, with a low acid buffering capacity indicative of increased caries risk. However, given the inability to address this, other than by increasing other preventive interventions such as fluoride, this would appear to be of limited clinical value.

Potentially, one of the best prospects for the future of caries prevention lies in the prospect of vaccination against the bacteria which cause dental caries, particularly *mutans streptococci* (Taubman and Nash, 2006). Several small scale

clinical trials have been carried out using active vaccines. These have shown promising results in inducing an immune response that inhibits the colonization of *mutans streptococci* in the oral cavity. At present dental caries is not considered a priority disease for vaccine development, given its non-life-threatening nature. However, there is potential in the future for development of a successful vaccine that could provide life-long protection against dental caries.

1.4.7 Medical history

1.4.7.1 Medical Risk Factors

A child's general health can impact on their risk for developing dental caries in many ways, even potentially before the child has teeth. For example a child being delivered preterm is not necessarily a risk factor for the development of dental caries. However, they are more likely to require special high calorie diets, have developmental defects of enamel or disabilities that may directly increase their caries risk (American Academy of Pediatrics, 2008).

It is well known that chronically ill children will often be given frequent cariogenic treats, by well-meaning parents and careers, as a comforting agent (Foster and Fitzgerald, 2005). In children with significant medical problems accessing dental care and maintaining oral health can often be perceived as a low priority. However, their medical condition may often make dental disease significantly more threatening and complicate their ability to receive dental treatment. It is important that every effort is made to minimise their potential burden of dental disease and other medical professionals can aid in achieving this by reinforcing the importance of good oral health to the child and careers.

The evidence relating to an increased caries risk in children with chronic diseases, like diabetes and asthma, is conflicting. In both these conditions there is a potential biological basis for an increased caries risk. In diabetic patients it has been reported that glucose levels in the gingival fluid and saliva is correlated with blood glucose and this suggests a mechanism for an increased caries risk in poorly controlled diabetics (Bolgul et al., 2004). Whilst asthmatic children may have a propensity to mouth breathing, leading to both a dry mouth with a

resultant increase in the consumption of potentially cariogenic drinks (Turkistani et al., 2010). Along with this, the common first line medication for asthma, β -adrenoceptor agonists can potentially increase the child's caries risk as β -adrenergic receptors are also present in the saliva glands, where they have an inhibitory effect on saliva excretion. However, in both asthma and diabetes the published longitudinal studies have given conflicting results with regard to the disease alone being a caries risk factor when compared to healthy controls.

The impact of poor dental health can be significantly amplified in some health conditions, in particular congenital heart defects, bleeding disorders and the immunocompromised (SIGN, 2000a). These groups are either at risk of severe complications (i.e. infective endocarditis or sepsis), or their health condition makes interventional dental treatment more risky (i.e. risk of haematoma formation). These factors make maintaining good oral health particularly important, and intensive preventive regimes must be effectively initiated.

Children with learning difficulties are often considerably more difficult to treat in the dental surgery and therefore ideally all attempts should be made to maximise the preventive treatment they receive to minimise any need for interventional treatment (Charles, 2010; Nelson et al., 2011). Unfortunately, these children are also often difficult to provide effective preventive therapies for as they may be difficult to manage at home and so an effective oral hygiene and dietary regime may be difficult or impossible for their parent/career to institute. Many of these children may have learning difficulties as a result of a wider syndrome and therefore have other compromising conditions, for example cardiac defects, which are common amongst children with Down syndrome. It is therefore important that this group of patients are treated as high caries risk and given as much professional support with preventive interventions as practical.

1.4.7.2 Medical Preventive Interventions

Sugar containing medications are of particular concern, as research has shown a relationship between the use of sugary medicines and dental caries (Hobson, 1985; Kenny and Somaya, 1989; Roberts and Roberts, 1981). Sugar based syrup medications can be used in children to increase acceptance and co-operation;

whilst for some medications the alternative formulation is tablets/capsules which a child may find challenging to swallow. Often these medicines will be taken last thing at night and therefore pose a significant caries risk, for example lactulose. For many medications sugar free preparations, defined as not containing fructose, glucose or sucrose, are available and should be recommended whenever possible (SIGN, 2000a). If a sugar free preparation is not available or not suitable for the individual patient, the child should be deemed to be at high caries risk and an enhanced preventive package instituted. This should include advice to minimise the caries risk from the medication; like taking the medication at meal times if suitable.

The full range of caries preventive techniques may also be utilised for medically compromised children, dependent upon their condition (AAPD Clinical Affairs Committee, 2012). Examples of conditions requiring modification of prevention techniques include; brittle asthmatics who may be sensitive some of the components of fluoride varnish (Colgate, 2013), or modifying the design of the standard toothbrush for children with limited dexterity (Damle and Bhavsar, 1995).

Chapter 2 – Background to Project

2.1 Background

In Scotland, childhood caries historically has been, and unfortunately remains, a significant child health issue. Over the past century advances in oral health, notably the introduction of fluoride, has changed childhood caries from an disease endemic in the population, to one increasingly concentrated to high risk groups in society. Traditional models for delivering dental care to children have failed to deliver the required preventive care to these children. This failure leads to children suffering potentially preventable morbidity and compounds treatment costs for the NHS.

There are arguments over how health promotion activities should be orientated: whether interventions should be universal in nature or targeted at specific groups, with potential impacts both positive and negative on health inequalities for both. The WHO Ottawa charter gives recommendations on how reorient health services to maximise their effectiveness in promoting health of patients. In Scotland these have been used to attempt to improve Scottish childhood oral health, along with taking a balanced approach to both universal and targeted interventions. To achieve these improvements will require the support of dental professionals to deliver the chairside preventive interventions required; particularly for those children who have experienced or are at risk of experiencing dental caries.

It has been a long held ambition that patients at risk of developing caries in the future could be accurately identified, allowing effective targeting of prevention. Many avenues have been explored for caries prediction including: clinical evidence; diet; social background; fluoride use; oral hygiene; saliva composition; and medical factors (SIGN, 2005, 2000a). Whilst these factors have been found to have a varying degree of predictive power, it is consistently shown that the most reliable predictor of future caries remains past caries experience - a less than ideal prediction factor. Based on this lack of an ideal caries predictor, all children should be considered “at risk of developing caries” and so require some preventive interventions. A CRA allows identification of children with an “enhanced” risk of developing caries, or who would face additional difficulties

and/or risks receiving operative treatment for caries. The CRA is therefore important in enabling the clinician in developing an treatment plan tailored to the individual patient (Evans et al., 2010). Fundamentally, dental professionals should aim to preserve the intact dentition as far as possible. To achieve this aim will require the consistent and systematic application of the full range of preventive interventions.

Oral health is not alone in facing difficulties in the application of best practice. We have exponentially gained more knowledge about the science of medicine over the past century and this has fed through to a system of medical practice in which it is no longer possible for one person to master it all. To handle this, a paradigm shift in how quality is managed in healthcare has been required. Previously healthcare systems achieved quality by training practitioners who were expected to be masters of all and then relying on quality by inspection to pick out those practitioners who did not meet the grade. No active consideration was given to the underlying system that produced the result. The new model for quality management in healthcare accepts that a modern healthcare service can no longer be provided by one master individual but rather relies on the effective interworking of a multitude of different teams and services. It can no longer be considered acceptable to only monitor the outcomes for quality; instead the different parts of the system need to be actively designed and monitored to ensure quality outcomes. If the system is intelligently designed then the aim is that best evidence based practice will be produced by default.

Oral health has lagged behind the rest of the medical field with regard to the adoption of this modern systems based approach to quality improvement. No literature was located on previously published reports of the utilisation of these types of improvement approaches in oral health. Improvement tools such as clinical audit are widely utilised in oral health and remain an important tool in the improvement armoury. However, these tools are limited when it comes to developing a deep understanding of the complex systems that often need to be dynamically addressed for enduring improvement.

2.2 2007 Departmental Survey

2.2.1 Methods – 2007 Departmental Survey

An survey of documentation of caries risk assessment and preventive care within the department of paediatric dentistry at Glasgow Dental Hospital and School in 2007 provided the initial impetus for this project (Shammaa et al., 2009). This first assessment of preventive care delivery was carried out amongst the postgraduate clinicians within the department completed by a team of investigators lead by CC. For this survey, data was collected from the first 25 patients who attended a postgraduate clinician's treatment session from the beginning of January 2007.

Case notes were reviewed for the presence of: a documented caries risk assessment, the presence of radiographs, toothbrushing instruction, toothpaste strength advice, application of fluoride varnish, diet advice, application fissure sealants and sugar free medicines advice. From this percentage completion rates were then calculated.

It is important to note that the criteria for radiographs, fluoride varnish application and fissure sealants used for this survey was different from the criteria used in subsequent surveys. This was due to the knowledge gained from this survey being used to guide development of more specific criteria in the subsequent prevention surveys.

2.2.2 Results – 2007 Departmental Survey

The 2007 departmental survey was the first assessment of preventive care standards on postgraduate clinics within the department. For this survey 25 case notes were retrospectively reviewed, and the investigators reported the following results (See Figure 8 and Table 11).

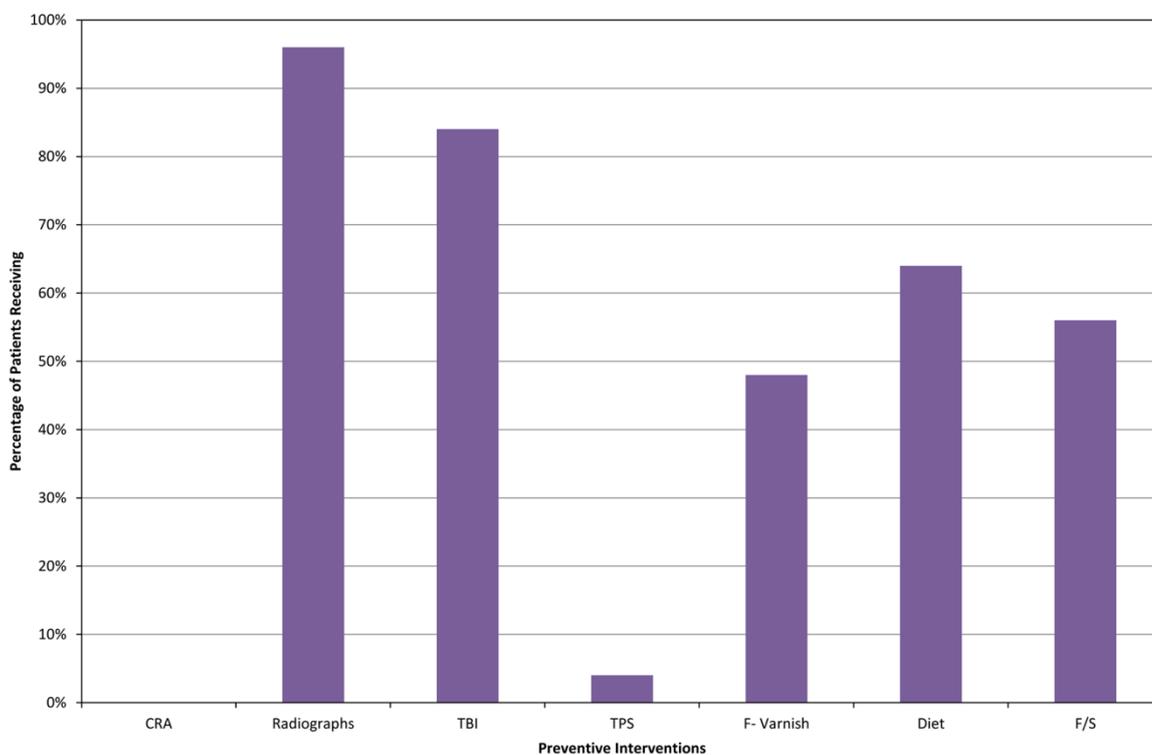


Figure 8 2007 Departmental Prevention Survey Results

Table 11 2007 Departmental Prevention Survey Results

Preventive Intervention	Percentage of Patients Receiving
CRA	0%
Radiographs	96%
TBI	84%
TPS	4%
F Varnish	48%
Diet	64%
F/S	56%

The immediate concern from these results was that none of the case notes sampled had a documented caries risk assessment. This result became one of the primary motives for initiation of the subsequent QI project. However, along with CRA, the majority of interventions examined required improvement; with only radiographs and toothbrushing instruction (TBI) approaching an acceptable level of performance in this audit.

2.2.3 Discussion – 2007 Departmental Survey

The 2007 survey was the first audit undertaken in the department to assess caries risk assessment and prevention, with the results presented at a regional audit meeting to encourage GDP's to undertake similar work to assess compliance with SIGN 47 and 83 Guidelines. That none of the patients had a

documented caries risk assessment was an alarming result, particularly for a specialist centre for paediatric dentistry. This provided a basis for universal agreement amongst the clinicians within the department that this needed to change. Following the survey a caries risk assessment tool was developed and initially directed at the undergraduate clinics. It was this tool that was used a basis for the original CARE sheet during the pilot project.

This survey found radiographs and TBI to be areas of strength; whereas fluoride varnish application, diet advice, fissure sealant placement, and especially toothpaste strength advice (TPS), all required improvement. The indication from these results was a lack of consistency in the application of the full range of preventive interventions. It was intended that the subsequent QI project would help ensure that every patient, every time, received a comprehensive package of all appropriate preventive interventions.

It is important to note that the criteria used in this survey were less specific than that used in later surveys. For example, the criteria for radiographs in the 2007 audit was that *any* relevant radiograph was taken, this in contrast to subsequent audits where radiographs had to be diagnostic of posterior caries, either bitewings or a panoramic radiograph. This change in criteria hampers direct comparison between the results of the 2007 departmental survey and subsequent surveys of preventive care.

Informal canvassing of opinion amongst clinicians within the department found they reported making a judgement on the CRA status of their patients – just not documenting it. However, this was felt to be unacceptable for three main reasons. Firstly, within a hospital based department multiple clinicians are involved in providing care to the patient, and so effective transfer of complete clinical information within the case notes is critical. Medico-legally what is documented in the case note is crucial in determining what treatment a patient may or may not have received. Finally, by failing to take a systematic approach to CRA and prevention, particularly within a busy department, this leaves clinicians vulnerable to simple errors of omission due to simply forgetting ask about a particular caries risk factor, or erroneously assuming that someone previously will have delivered fundamental preventive care.

Chapter 3 – The Pilot Project

3.1 Background the Pilot Project

Based on the results of the 2007 departmental survey, it was felt that CRA and preventive care documentation required to be targeted for improvement. As there were no previous examples to copy, a pilot improvement project was instigated in 2008-09, to demonstrate that a systems based approach could be successfully employed in tackling this issue. The abstract from the article detailing the pilot project is given below, with the entire article reproduced in appendix 4.

Objective To evaluate the impact of a continuous improvement project to improve completion of a caries risk assessment (CRA) and to assess its impact on delivery of dental caries prevention. **Design** Single centre clinical improvement project. Setting was a paediatric dental department within a UK dental hospital over the course of 2008-2009. **Subjects (materials) and methods** Continuous monitoring of documentation of a CRA was instigated and results fed back to clinicians. Tools were developed to structure the process of CRA. After six months of intervention, a comparison of preventive care to a pre-intervention sample was undertaken. **Main outcome measures** The main outcome measure was completion of a CRA. Comparison was also made with pre-intervention data on levels of preventive care received. **Results** Over the 12 month project the mean rate of CRA completion improved from 30% over the first 6 months to 73% in the second 6 months. Compared to the pre-intervention sample, all items of the caries prevention package had improved, with delivery of toothpaste strength advice (16% vs 60%, $p = 0.001$) and diet advice (32% vs 70%, $p = 0.004$) improving significantly. **Conclusion** By targeting and improving CRA completion the quality of preventive care delivered has also significantly improved. (Keightley et al., 2012)

The success of this pilot project led to the establishment of a full improvement project, which was instigated under the name Caries Assessment Risk Evaluation (CARE) project. The establishment of the CARE project in August 2009 and the first 24 months of progress, till August 2011, will be documented and discussed here.

3.2 Pilot Monitoring of Caries Risk Completion

3.2.1 Methods – Pilot Monitoring of Caries Risk Completion

Over the course of the pilot project a number of CARE Tools were developed. The intention of these CARE Tool was to ease to process of documenting a CRA and so help clinicians within the department achieve the desired improvements. Full detailed of the development of these CARE tools is given in appendix 4. The success of these tools was monitored by regular monitoring of CRA documentation rates.

For ease of sampling during the pilot a judgement sample was collected by an investigator who would select two patient charts at the end of every morning and afternoon session. This judgement sample was determined by the investigator attempting to select a representative sample of the different types of clinic over the course of a week. At the end of each session a clinic would be chosen and the investigator would ask to review the first two case notes that came to hand. The investigator would then examine these two case notes for the presence of a documented CRA. This sampling procedure was carried out every second week during the pilot. Data was entered into a secure database (Microsoft Access 2008, Redmond, Seattle, USA) with results plotted onto a run chart using standard spread sheet software (Microsoft Excel 2008, Redmond, Seattle, USA).

3.2.2 Results – Pilot Monitoring of Caries Risk Completion

The run chart for the pilot project is shown in Figure 9.

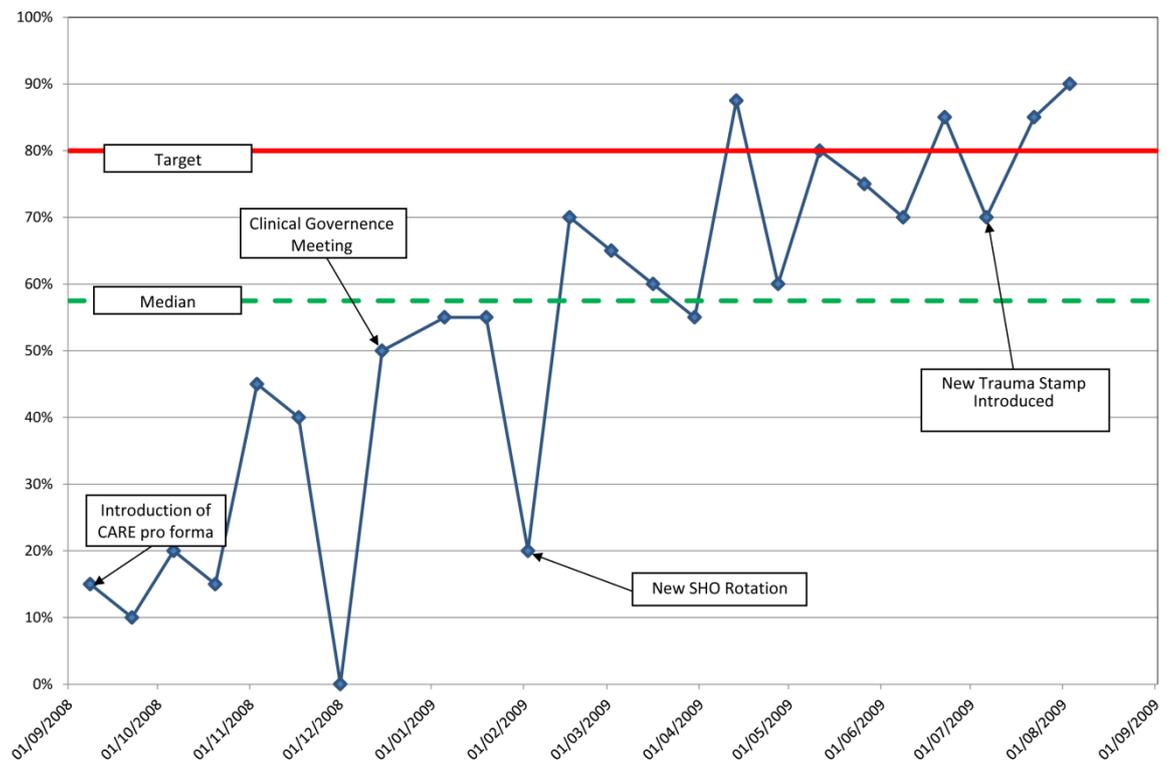


Figure 9 Pilot Project Run Chart

Rules for detection of special cause variation within run charts will be discussed in detail in section 5.7.2 (See Page 110). However, the overall trend over the pilot is one of gradual and nearly constant improvement from a very low starting point of 15% to 90% by the end of the pilot.

3.3 2008-09 With and Without CARE Tool Survey

3.3.1 Methods – 2008-09 With and Without CARE Tool Survey

In January 2009, 6 months into the pilot project, case notes of 40 patients were reviewed. These case notes were stratified into two groups; 20 patients, who were known to have a completed CARE tool in October 2008, compared with 20 patients known not to have a completed CARE tool in October 2008. These patients were selected from the secure database, maintained as part of the data sampling for the run charts. The patients were selected from October 2008, to allow a four month period for any preventive interventions to be completed.

Cases notes were reviewed against the following criteria:

- **Radiographs** - was there a radiograph diagnostic of posterior caries, either bitewing or panoramic, taken within the last 2 years, or documented justification for not taking one.
- **Toothbrushing instruction (TBI)** - was there a record of the patient being given toothbrushing instruction.
- **Toothpaste strength advice (TPS)** - was there any record of advice relating to the appropriate strength of fluoride toothpaste the patient should be using.
- **Fluoride varnish (F⁻ Varnish)** - was fluoride varnish applied at least twice within the 12 months of either 2007 or 2010, or was there documented justification for not applying it (i.e. contraindicated by medical history, lack of co-operation or being applied in primary care). For patients who attended for less than 12 months, but for more than 6 months, only one application needed to be achieved. Whilst for any patient who attended for less than 6 months, there did not have to be a documented application of fluoride varnish.
- **Diet** - was there any record of advice relating to dietary habits.
- **Fissure sealants on first permanent molars (F/S on FPMs)** - were fissure sealants present or applied to the occlusal surfaces of the first permanent molars. If the patient did not have first permanent molars, or they were unsuitable for sealing (i.e. unerupted, extracted, partially erupted, filled or carious) then a positive result was still recorded. However, all four first permanent molars had to be either sealed or have an appropriate reason not to be sealed, for an overall positive result to be recorded for that patient.

Fluoride supplements and sugar free medicines were excluded, as these preventive interventions are not universally required and only given when deemed clinically necessary.

Data were entered directly into a spread sheet (Microsoft Excel 2008, Redmond, Seattle, USA), with percentages calculated for rates of completion of the various preventive interventions.

3.3.2 Results – 2008-09 With and Without CARE Tool Survey

For this assessment 40 case notes of patients seen in October 2008 were reviewed four months later in January 2009. These case notes were grouped into two; 20 case notes of patients known to have a CARE sheet completed and 20 case notes of patients known not to have a CARE sheet (See Figure 10 and Table 12).

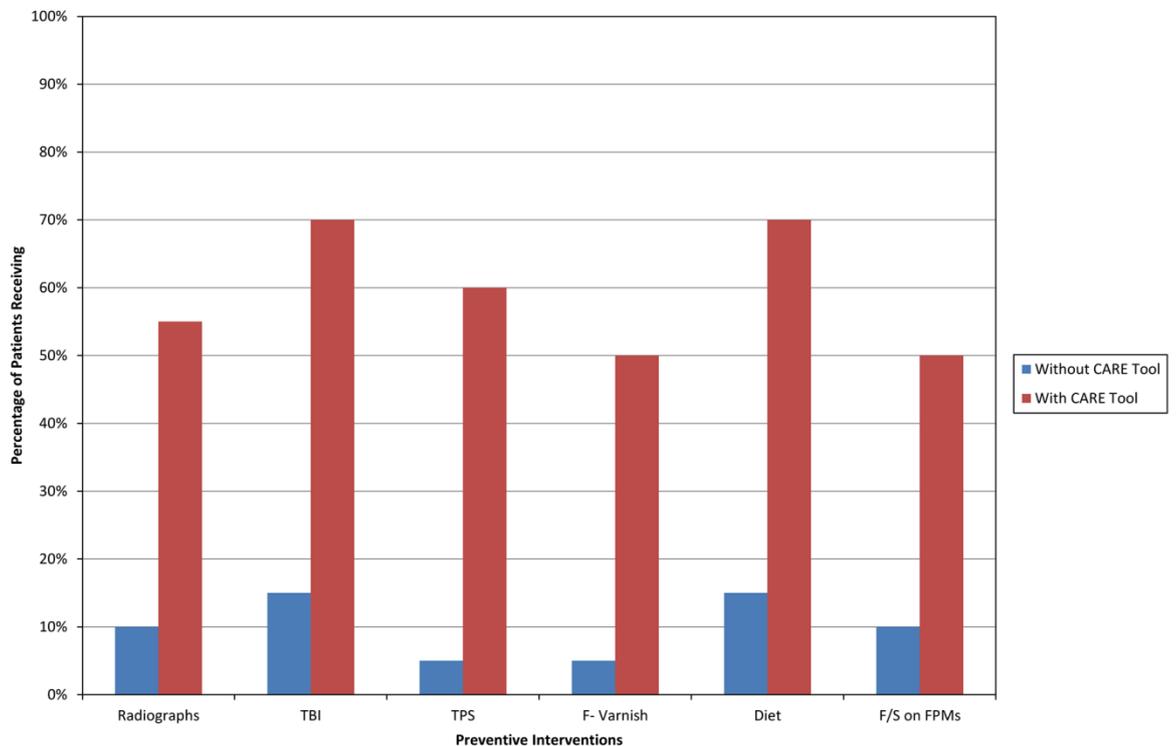


Figure 10 2008-09 With and without CARE Tool Survey Results

Table 12 2008-09 With and without CARE Tool Survey Results

Preventive Intervention	Percentage of Patients Receiving	
	With CARE Tool Completed	Without CARE Tool Completed
Radiographs	10%	55%
TBI	15%	70%
TPS	5%	60%
F Varnish	5%	50%
Diet	15%	70%
F/S on FPMs	10%	50%

3.3.3 Discussion – 2008-09 With and Without CARE Tool Survey

Although statistical analysis was not carried out for this assessment, there is a very large difference between the patients with a CARE sheet and those without. Therefore, these results are highly suggestive of a completed CARE Tool leading to patients receiving more preventive interventions. These results are not directly comparable with the 2007 survey results, as different assessment criteria was used by different examiners. For this survey documentation of a caries risk assessment was not examined, this was because the way patients were selected. All patients with a completed CARE tool had a completed CRA, whilst those without a completed CARE tool did not. This also means that there is an element of selection bias within these results as the type of patient who does not get a CARE sheet completed, is likely to also be the type of patient who does not get many preventive interventions documented.

It was felt that these results would be a powerful motivator for clinicians to complete a CARE sheet, appealing to both the “beliefs about consequences” and “motivation” behaviour domains. Therefore, these results were highlighted during the CARE launch event (See 7.1.8 Dissemination of Results, Page 130).

Chapter 4 – Aims of CARE Project

4.1 Primary Aim

What are we trying to improve?

The documentation of a caries risk assessment for all patients attending the department of paediatric dentistry.

Why do we need to improve?

We believe a caries risk assessment is the crucial first step in determining the caries preventive care our patients should receive.

Where is the improvement going to occur?

On all clinics running in the department of paediatric dentistry.

By when will the improvement occur?

By August 2011.

By how much will we improve?

95%+ of patients will have a caries risk assessment completed by our August 2011 deadline.

4.2 Secondary Aim

To assess whether the QI work directed at improving CRA documentation rates led to any subsequent improvement of documented rates of caries prevention interventions being delivered to patients attending the department.

Chapter 5 – Setup of CARE Project

5.1 Ethics

A protocol (See Appendix 4) was developed for this project which was submitted to both the NHS West of Scotland Research Ethics Service, the local hospital audit committee and the University of Glasgow, Faculty of Medicine, Ethics Committee. All agreed that the work proposed constituted audit/quality improvement and as such did not require formal ethical approval (See Appendix 6). The project protocol was submitted to and approved as an on-going project by the local clinical governance committee at Glasgow Dental Hospital and School.

5.2 Institute for Healthcare Improvement Open School

As part of the preparation for the CARE project, the Institute for Healthcare Improvement Open School online learning course was completed (See Appendix 7). This online course provided basic teaching in QI topics, including: leadership; managing healthcare operations; patient and family centred care; patient safety; and quality improvement.

5.3 Scottish Patient Safety Programme Secondment

To help enhance our understanding of QI implementation, it was important to learn from on-going QI projects in other local healthcare institutions. The most prominent being the Scottish Patient Safety Programme (SPSP); implemented within all acute hospitals in Scotland. To facilitate this learning opportunity a secondment was organised with one of the local SPSP co-ordinators. The role of an SPSP co-ordinator is to support the improvement efforts within the hospitals in their region. At the time of secondment the main focus of the SPSP was in Intensive Care Units (ICU) and High Dependency Units (HDU). The aim of the secondment was to gain first hand knowledge of what was happening within the SPSP at the time, by observing visits by the SPSP co-ordinator to one of each of these units. This would illuminate how the SPSP was identifying and overcoming barriers to improvement, and this knowledge would be transferable to the running of the CARE project.

5.3.1 ICU Visit

The lead ICU consultant for improvement and the ICU manager were present at the ICU meeting visit. Discussions began with the ICU consultant describing their recent secondment to observe QI efforts in Swedish hospitals. They reported being extremely impressed by QI culture within the hospitals, with dedicated time for QI being part of every member of staffs' job plan; from the clinical leads to the hospital porters. They then moved on to discuss one of the main improvement targets within the ICU, which was maintaining patient's blood glucose levels within a clinically appropriate range. It was decided that the initial target of 95% compliance with the target range was unrealistic, primarily due to the wide variety of patient medical backgrounds. Therefore, the target was revised to 80% which was felt to be an achievable level.

The next issue was the difficulties the ICU team was having in achieving their hand hygiene target. They reported that their present difficulty was with clinicians visiting the department not washing their hands on entry. Discussions centred around how this could be addressed, with one suggestion being that notices could be put up "naming and shaming" those groups or individuals who had been observed not carrying out hand hygiene on entry to the department. This was discounted as likely to cause resentment amongst those identified by the "naming and shaming" exercise. Instead it was decided to ensure that junior doctors along with the ICU consultants were adequately trained regarding hand hygiene in their hospital induction, and to work with the nursing staff to empower them to approach any clinician identified as entering the department without washing their hands.

Finally, the discussion turned to the daily goals sheet that was being introduced to the department. A daily goal for each patient was to be set by the patient's consultant at morning rounds, an example of this could be to reduce the patient's dose of sedative medication, and this would be recorded on the patient's daily goal sheet. The nursing staff could then refer to the daily goal sheet throughout the day, and record the progress in implementing the goal. At the following day's ward round the daily goal sheet could then be reviewed before setting the next goal. It was reported that the nursing staff were extremely keen on the daily goal sheet, as it provided a continuity and direction

for treatment throughout the day and across shift changes. It also gave the nurses a basis to provide useful information to relatives when they were asked about progress during visits. However, some of the ICU consultants were reported to be reluctant to complete a daily goals sheet; feeling it was an additional burden of paperwork and that the patient's treatment was likely to change anyway. It was decided to tackle this issue by collecting opinions from the nursing staff on the benefits of the daily goals sheet, and presenting this to the ICU consultants.

5.3.2 HDU Visit

The HDU visit was a one-to-one meeting with the ward sister, reflecting that involvement of HDU in the SPSP was a relatively new development, and it was observed that the level of commitment from HDU staff was not as well developed. The first concern raised by the ward sister was that initial improvements relating to hand hygiene were slipping back. After discussion it was identified that one of the primary reasons for this was that the new rotation of junior doctors had started in the department without receiving adequate education at their induction. This barrier was addressed by approaching the lead consultant with a proposal for an education event, along with the introduction of a hand hygiene component into the junior doctors' induction programme. The ward sister was also concerned about displaying data that showed a negative trend relating to hand hygiene. Here it was felt that you had to be open and honest about the data, as the prominence of the data itself is likely to act as a motivator for staff. Staff will want to see the data improve and will know if they are personally contributing to the negative trend. However, they also need to believe in the data, so it was agreed that the method of data collection should be frequently discussed, and the involvement of as many staff as possible sought in collecting the data.

5.3.3 Knowledge Gained

The secondment demonstrated a host of barriers to improvement encountered in the healthcare setting. Table 13 shows examples of how in relation to hand washing, these barriers arose, in every one of Michie *et al.*'s domains (Michie *et al.*, 2005).

Table 13 Hand Hygiene Behaviour Domains and Barrier Identified on SPSP Secondment

Behaviour Domain	Identified Barrier	Change
Knowledge	<i>Did the junior doctors know about hand washing policies within departments?</i>	Training
Skills	<i>Did junior doctors know how to carry out appropriate hand washing?</i>	Training
Social/Professional Role and Identity	<i>Is it appropriate for nurses to tell doctors to wash their hands?</i>	Department Culture
Beliefs About Capabilities	<i>Are the nurses comfortable telling a doctor to wash their hands?</i>	Department Culture
Beliefs About Consequences	<i>If a nurse does tell a doctor to wash their hands will the doctor then make life difficult for that nurse?</i>	Department Culture
Motivation and Goals	<i>How important do staff feel it is that they wash their hands?</i>	Training Department Culture
Memory, Attention and Decision Processes	<i>Are staff too busy to remember to wash their hands?</i>	Department Culture
Environmental Context and Resources	<i>Are hand washing stations readily available?</i>	Resources
Social Influences	<i>As a group are the staff committed to achieving the hand washing targets?</i>	Communication of Data Department Culture
Emotion Regulation	<i>Do the staff feel that hand washing is important?</i>	Training Department Culture
Behavioural Regulation	<i>Is the data relating to the hand wash targets being presented as a priority?</i>	Communication of Data Department Culture
Nature of Behaviour	<i>Have staff developed poor hand hygiene habits that need to be changed?</i>	Training

Many of these barriers could be addressed via training, ensuring resources are available, and appropriate communication of data. However, one of the key behaviour changes needs to be normalising the culture within the department around the expected behaviour. The experience on the secondment was that this can only begin to be achieved once the other elements, training, resources and data, are adequately in place to facilitate any shift in underlying culture.

5.4 The CARE Project Setting

The department of paediatric dentistry is primarily based at Glasgow Dental Hospital and School (GDHS), where patients are seen on an outpatient basis for assessment and treatment under both local anaesthesia and inhalation sedation. The department is also responsible for providing care at Yorkhill, Royal Hospital for Sick Children. As well as seeing patients on an outpatient basis for assessment and treatment under local anaesthesia, care is provided for admitted inpatients. At Yorkhill dental care is provided under general anaesthesia (GA) for patients initially assessed within the outpatient department at Yorkhill or at the dental hospital. Dental care under GA either consists of simple extractions only on a routine exodontia list, or a comprehensive care GA list with patients requiring restorative care, more difficult extractions or minor oral surgery procedures, or those who have more complex medical needs. The department also provides anaesthetist led intravenous propofol sedation services, primarily for anxious adolescents at Gartnavel hospital.

During the time period in question, the department was led by 5 consultants in paediatric dentistry, along with 1 specialist in paediatric dentistry. There were 5 registrars (SpR) undergoing training either to specialist or consultant level. Finally there were the Senior House Officers (SHO), who are junior clinicians, not yet definitively committed to a speciality training programme. The SHO's rotate through the various departments within the dental hospital on a 6 monthly basis. During the period of the project there were 4 SHOs working within the department. Clinical activity is supported by a team of dental nurses. This consisted of 1 team leader, 5 permanent dental nurses, along with varying numbers of rotational and trainee dental nurses.

The department is also responsible for undergraduate training in paediatric dentistry. This involves significant liaison with colleagues in the community dental service (CDS). The first student experience of treating paediatric patients occurs in 3rd year at community outreach clinics. In 4th year the students then return to GDHS for paediatric clinics within the department itself and further teaching within different community outreach clinics. This is followed by more outreach paediatric clinics in final year. Clinic teaching both at outreach and within GDHS is undertaken by specialists and consultants, but

the majority is provided by community clinicians within the CDS. Final year students are also offered the opportunity to undertake a paediatric special study module in final year, which allows them to observe and participate in more specialist treatments both at GDHS and Yorkhill.

5.5 Working Group

The CARE project was led by a core working group throughout, consisting of the lead investigator (AK) and supervisor (CC) and rotational SHO's. Other members of the dental team were involved at various times depending on the current status and demands of the project. The primary QI tools used for the CARE project were the PDSA method and run charts which guided a system based approach to achieving our improvement aim.

5.6 CARE Toolkit

The CARE toolkit was the primary intervention for achieving our aims. These are a range of tools developed over the course of the pilot project, intended to encourage behaviours relating to our aims; in relation to both CRA and prevention documentation. By the end of the pilot project three different CARE tools existed, which along with a CARE training manual formed the CARE toolkit; the development of which is detailed in Keightley *et al.* 2011 (See Appendix 4).

For the launch of the CARE project, the CARE sheet, was revised based on clinician feedback (See Figure 11, Figure 12 and Table 14. Images of CARE Toolkit reproduced in full in Appendix 8). The main features of the CARE sheet included recording of patients; height and weights, CRA, prevention plan, diagnosis, treatment plan, along with a log to record when different preventive interventions were delivered. The intention was to make the CARE sheet as useful as possible to clinicians in managing the long term care of patients, so that they would refer to it regularly at every visit, rather than completing it once and then ignoring it.

Figure 11 Pilot project CARE Sheet (Front and Back)

Figure 12 Revised CARE Sheet (Front and Back)

Table 14 Barrier to Use of Pilot CARE Sheet and Changes Implemented

Identified Barrier to Use	Change(s) in Revised CARE Sheet
CARE sheet not regularly referred to after initial completion.	<ul style="list-style-type: none"> Removed 2nd caries risk assessment and prevention plan. Added diagnostic summary and treatment plan.
Preventive items on treatment plan potentially skipped.	<ul style="list-style-type: none"> Placed diet advice, toothpaste strength advice and fluoride varnish, as default option on the treatment plan to encourage their completion. Treatment plan structured so items could be ticked off as completed.
SHOs often unsure what to do once patient's treatment plan completed.	<ul style="list-style-type: none"> Added "On Treatment Plan Completion" section, so that a follow up plan could be specified.

The other CARE tools, the primary care provider communication sheet (PCPCS) (See Figure 13) and the trauma stamp (See Figure 14), were both used unchanged at the launch of the CARE project. The PCPCS was designed primarily for use on the paediatric assessment clinic and the emergency casual clinic. It is produced in triplicate form to facilitate quick communication of clinical findings along with a caries risk assessment and prevention plan, back to the referring practitioner. Being in the form of a triplicate pad, it avoids additional demands on secretarial support and produces a copy for the notes, a copy for the referring practitioner and a copy for the parent.

The CARE training manual was updated for the new CARE sheet, but otherwise remained unchanged (See Figure 15, with full copy of CARE training manual in Appendix 8). Existing members of staff had been involved with development of these tools during the pilot, and were given further training regarding the modification for the start of the CARE project at a launch event (See 7.1.8 Dissemination of Results, Page 130). New staff arriving in the department routinely received induction training, part of which included discussion of the CARE project and a copy of the CARE training manual was given for reference.

Glasgow Dental Hospital & School
778 Sauchiehall Street
GLASGOW G2 3JZ

DEPARTMENT OF PAEDIATRIC DENTISTRY ☐ Glasgow Dental Hospital & School
GDP Information ☐ Glasgow Dental Hospital & School
Parent Information ☐

Date:

The above patient was seen in the Department of Paediatric Dentistry at Glasgow Dental Hospital on the following date:

Examination revealed: CARIES: TRAUMA: OTHER:

Treatment will be as follows: (Please circle)

1. Composite Resin Core under GA or FESIC	2. Management of trauma under CO2R
3. Extraction under GA or FESIC	4. Seal treatment and/or restorative (CO2R) Paediatric Clinic

(Children listed in box 2 above, the responsibility for the patient's routine examinations, routine treatment and pain management remains with the primary care provider)

PREVENTION ADVICE

This patient's caries risk is currently: HIGH MODERATE LOW (This risk should be regularly re-assessed)

The following Prevention Plan is recommended to be written up in the Patient's Case notes in your nearest BDSU folder:

Prevention Plan	Frequency (circle as appropriate)		
	6 months	12 months	18 months
RECALL PERIOD	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
RADIOGRAPHIC PERIOD	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
FLOSSING VARNISH (topical)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
TOOTH PASTE STRENGTH	1,000 ppm F	1,000 ppm F	1,000 ppm F
TOOTHBRUSHING INSTRUCTION	YES	NO	NO
DINARY COUNSELLING	YES	NO	NO
FLUORIDE SEALANTS TO BE APPLIED (where applicable)	YES	NO	NO

Thank you for your collaboration in improving this patient's oral health

(SIGN AND DATE)

Figure 13 Primary Care Provider Communication Sheet (PCPCS)

TOOTH				
SINUS				
COLOUR				
TTP				
MOBILITY				
EPT				
ECL				
P. NOTE				
RADIOGRAPH				
CARIES RISK	HIGH	MEDIUM	LOW	

Figure 14 Trauma Stamp

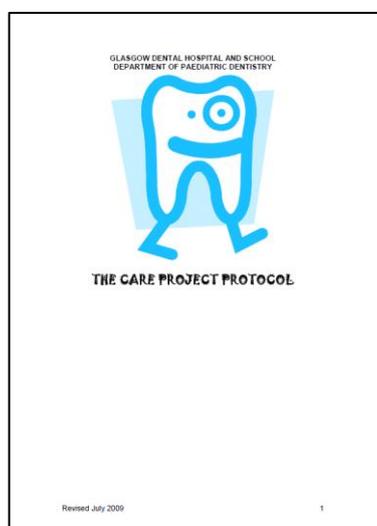


Figure 15 CARE Project Training Manual

5.7 Monitoring of Caries Risk Completion

The primary aim of the project was to improve the rates of caries risk assessment documentation. The methods employed to achieve this were the identification of barriers to completion and the introduction and testing of change concepts using the PDSA methodology to address these barriers. This was supported by the monitoring of progress using run charts. The progress of the project was regularly disseminated, using a variety of methods, to ensure staff awareness of the project.

Data were segmented into 6 month periods (7 months for the final February '11 to August '11 period), as this coincided with the change in SHO rotations. This staff change made it an ideal opportunity to reflect on progress and introduce

new interventions. Aggregate data on caries risk completion rates was analysed by staff group and clinic type to provide further information at the end of these periods.

5.7.1 Data Sampling

The importance of useful data is critical for QI projects. In our pilot project we relied on a judgement sample to obtain the data to guide the project (See Keightley *et al.* - Appendix 4). For the CARE project, we developed a new data collection system intended to address some of the drawbacks of the pilot system (See Table 15).

Table 15 Pilot Data Sampling Limitations and Changes for CARE Project

Limitation	Pilot Data Sampling Reason	Change for New Data Sampling
Bias	Selection of notes by judgement sample (See 3.2.1).	Notes selected at random.
Bias	Notes for examination limited to those readily available to examiner.	Once notes selected, these were examined regardless of location.
Bias	Certain clinicians may have completed a CARE tool subsequent to notes being examined on the clinic.	Notes requested for examination once clinician has returned them to file.
Infrequent sampling	Sampling done on fortnightly basis.	Sampling to be done on weekly basis.

This new data sampling system consisted of the following steps:

1. Over the course of a week the hospital numbers of all patients who attended the department were collected from the hospital computerised appointment system and entered into a secure database (Microsoft Access 2008, Redmond, Seattle, USA).
2. At the start of the subsequent week, the database was queried to produce a list of unique attendee hospital numbers for the previous week. A random number generator (www.random.org) was then used to select 5 hospital numbers from this list.

3. The case notes for these 5 hospital numbers were then requested from medical records.
4. Once the notes were available, they were reviewed for the presence of a documented caries risk assessment, along with the clinic type attended and the grade of staff who saw the patient at that visit.

This process was repeated every week on a continual basis. From the 5 case notes reviewed for each week a percentage with a completed caries risk assessment was calculated and this was used to monitor the progress of the project.

5.7.2 Run Charts

As discussed previously (See 1.3.4.2 Statistical Process Control, Page 45), the run chart is simple and easy to construct and can be used for any type of measurement. At its most basic level, a run chart consists of a line plot of a measurement over time. The measurement in the case of the CARE project was the percentage of sampled case notes that had a completed CARE tool. The median of the measurements were plotted as a centre line. A target line was placed to indicate the desired level of performance. For the CARE project this was 95% and often the charts were annotated with significant events.

A variety of rules can be used to identify if special cause variation is acting on the system being measured (Clinical Indicators Support Team, 2011). A number of run chart rules utilise what are called “useful observations”, these being any data point that does not lie on the centre line.

Number of Runs - A run is one or more consecutive data points on the same side of the median line. The number of runs on a chart should be counted and then compared to an expected range of results, found by using the following formula (See Figure 16).

Figure 16 Formula for Calculating Expected Number of Runs

Let r = number of useful observations

Lower limit for number of runs = $\frac{r}{3}$ (rounded down)

Upper limit for number of runs = $\frac{2r}{3}$ (rounded up)

If the system is working under common cause variation the data point should fall on either side of the median line in a random fashion and therefore the number of runs should fall within an expected average range based on the number of observations. However, if the number of runs falls outside this expected range, this indicates that special cause variation is acting on the system.

Shift - Useful observations are defined as those data points either side of the median line, but not directly on it. If more than 7 consecutive useful observations fall to one side of the median line, this indicates special cause variation.

Trend - If more than 7 consecutive useful observations are increasing or decreasing, this indicates special cause variation.

Zig-Zag - If more than 14 consecutive useful observations alternate between above and below the centre line in a zig-zag pattern, this indicates special cause variation.

Wildly Different - A subjected opinion that a lone useful observation is markedly different from the expected pattern, this indicates special cause variation.

Cyclical Pattern - If a regularly occurring pattern can be identified within the data, for example differing results at weekends compared to week days, this indicates special cause variation.

Identification of any of the above rules within your run chart is suggestive that a special cause variation applies and merits further investigation.

5.7.3 CARE Tool Completion by Staff Group

As part of our on-going monitoring we regularly recorded the completion of a CARE tool by grade of staff, these being: undergraduate, SHO, SpR, Specialist, Consultant and Hospital Practitioner.

Aggregate results were produced for each of these 6 groups, showing numbers of their patients notes reviewed and percentage of their patients having a completed CARE tool. This was done throughout the project at the end of each 6 month block, as well as for the whole 25 months of the project. This provided additional useful information to help identify if there were particular barriers relating to one group of clinicians during the project.

5.7.4 CARE Tool Completion by Clinic Type

Along with grade of staff, the type of clinic the patient was seen on was also recorded. These included: consultant clinic, treatment session, sedation, casual clinic, paediatric assessment and undergraduate clinic. Again this also allowed for aggregate results showing the patient notes reviewed for that type of clinic and completion rates of a CARE tool on those clinics. As for staff groups, this was done at the end of each 6 month block, and at the end of the 25 months of the project.

5.8 Monitoring of Caries Prevention

The secondary aim of the project was to assess the subsequent impact the project had on improving rates of documented delivery of caries prevention interventions. This was undertaken by carrying out a number retrospective surveys on samples of patient case notes. Prior to the CARE project this had been done; in 2007 as a departmental audit (See 2.2 2007 Departmental Survey, Page 90), and during the 2008-09 pilot project (See 3.3 2008-09 With and Without CARE Tool Survey, Page 95), where a comparison had been made between patients with a completed CARE tool and those without. During the CARE project the comparison between patients with a completed CARE tool and those without was repeated for 2009-10 (See 7.1.7 2009-10 With and Without CARE Tool Survey, Page 128). Finally a formal assessment was completed by evaluating performance prior to any QI interventions in 2007 with those after

establishment of the QI programme in 2010 (See 7.4.7 2007 v 2010 Survey, Page 162).

Chapter 6 – Overview CARE Project

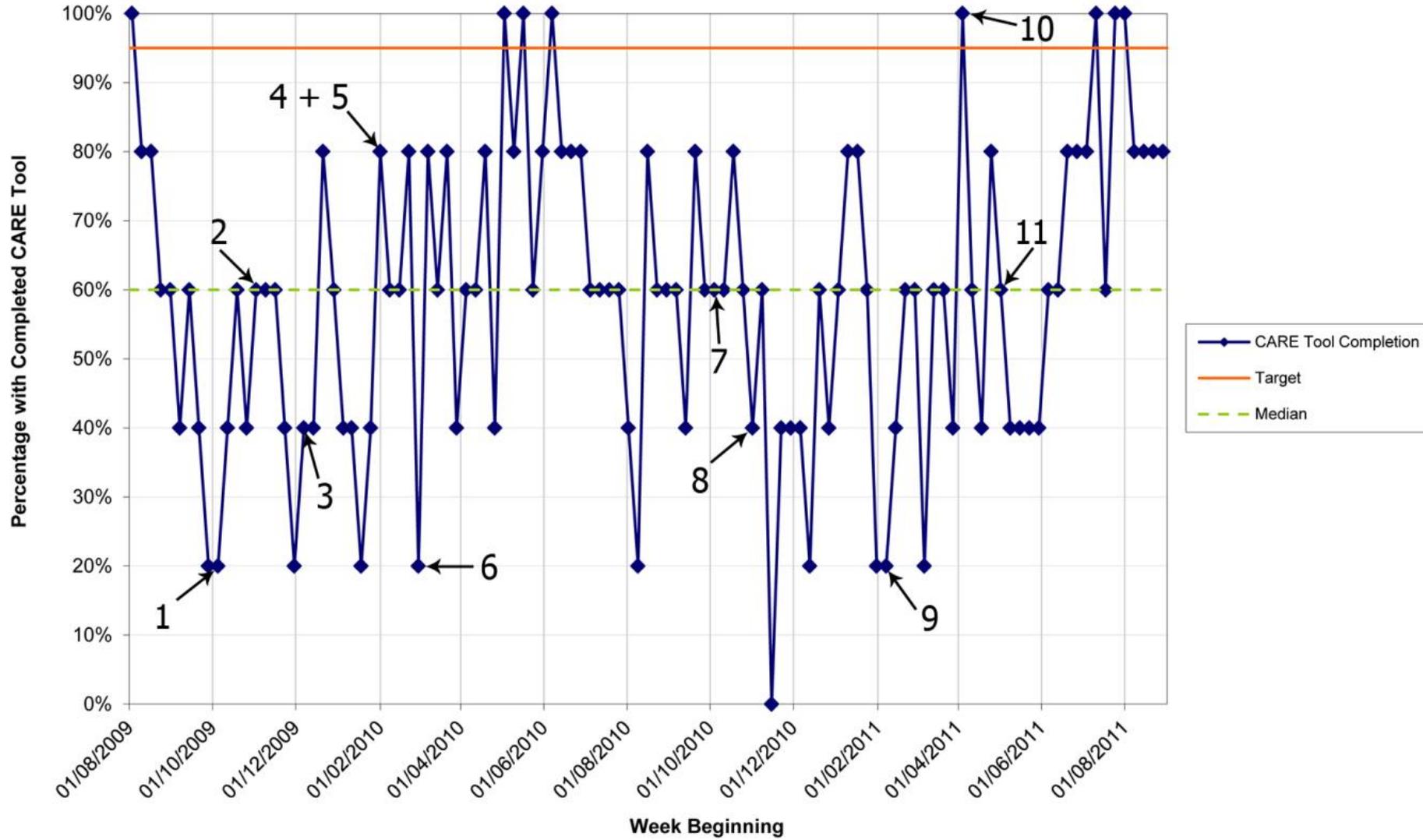


Figure 17 Full CARE Project Run Chart
 Annotated numbers relate to introduction of Change Concepts as displayed in Figure 18

Barriers

Change Concepts

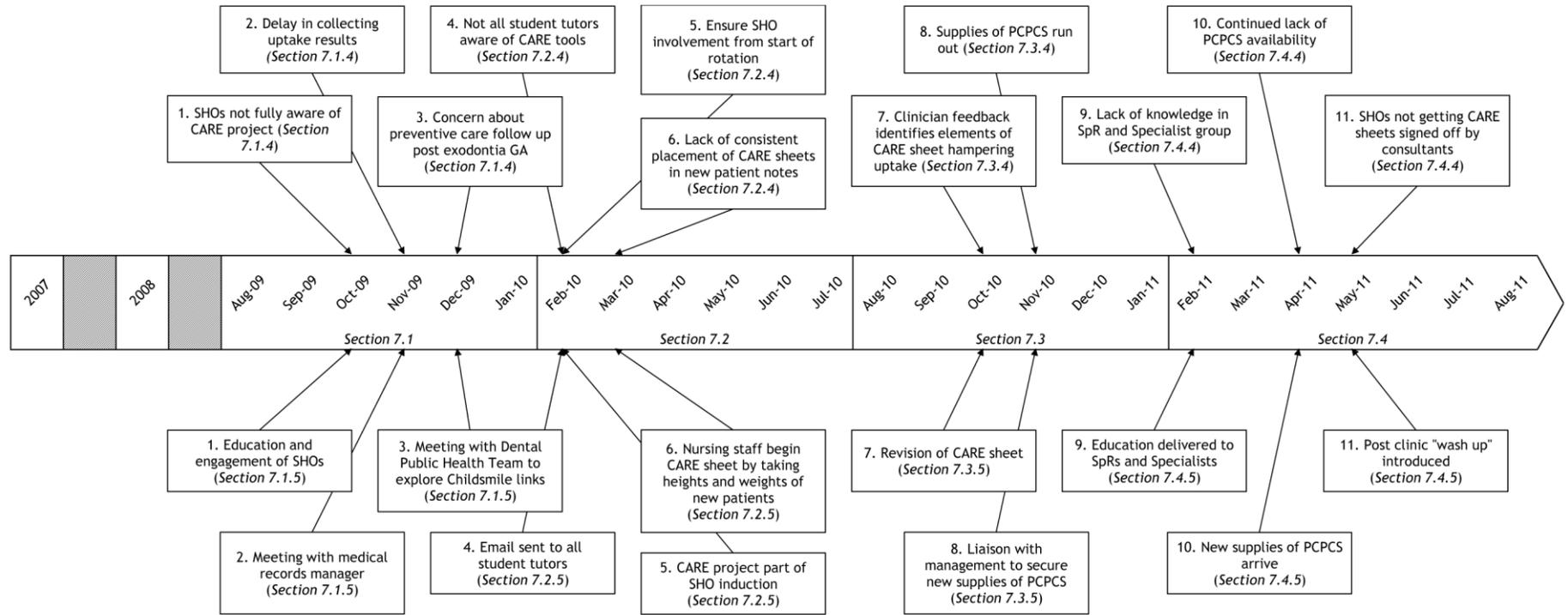


Figure 18 CARE Project Timeline - Barriers and Change Concepts

Surveys
Dissemination

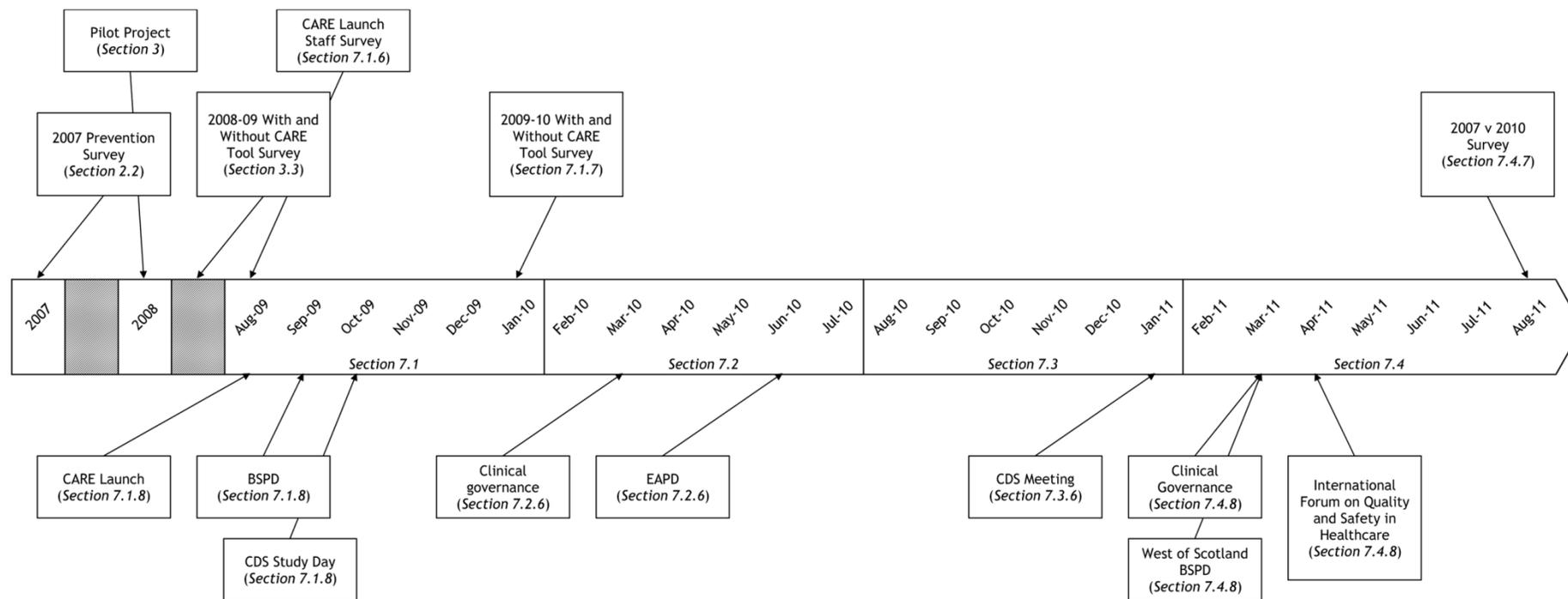


Figure 19 CARE Project Timeline - Surveys and Dissemination

Chapter 7 – Implementation of CARE Project

7.1 August 2009 to January 2010

A summary of the barriers identified and changed concepts introduced in this period are given below (See Table 16).

Table 16 Barriers and Change Concepts August 2009 to January 2010

Barrier	Behaviour Domain	Change Concept	Date Implemented
1. SHOs not fully aware of CARE project.	Knowledge	1. Education and engagement of SHOs.	October 2009
2. Delay in collecting uptake results.	Environmental Constraints	2. Meeting with medical records manager.	November 2009
3. Concern about preventive care follow up post exodontia GA.	Environmental Constraints	3. Meeting with Dental Public Health Team to explore Childsmile links.	December 2009

7.1.1 Run Chart

The run chart for this period with the introduction of change concepts from Table 16 annotated, is seen below (See Figure 20).

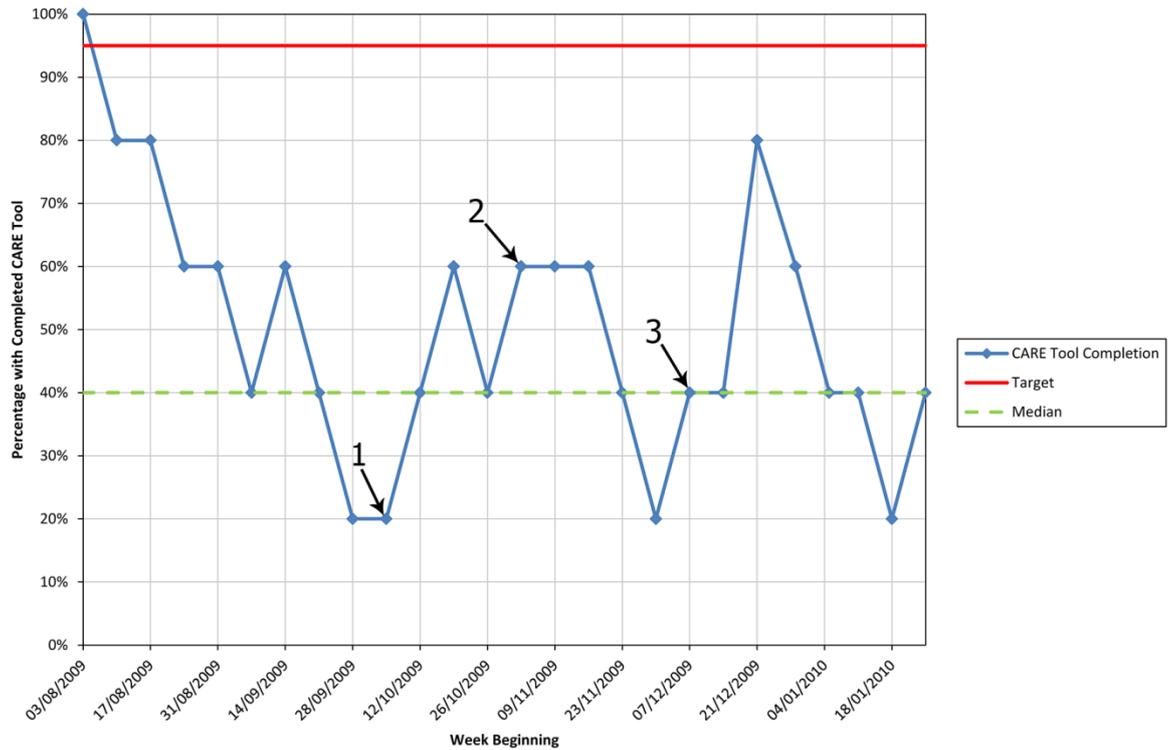


Figure 20 August 2009 to January 2010 Run Chart
Annotated numbers relate to implementation of Change Concepts as list on Table 16.

From Figure 20 the median for this time period is 40%, whilst the number of useful observations was counted as 16. This value was then be used to calculate a lower and upper value for the number of expected runs for the CARE project run chart.

$$\text{Lower Limit for Expected Runs} = \frac{16}{3} = 5.33 \text{ (Rounded Down} = 5)$$

$$\text{Upper Limit for Expected Runs} = \frac{2 \times 16}{3} = 10.67 \text{ (Rounded Up} = 11)$$

The number of runs on the CARE project run chart was then found, as shown in Figure 21.

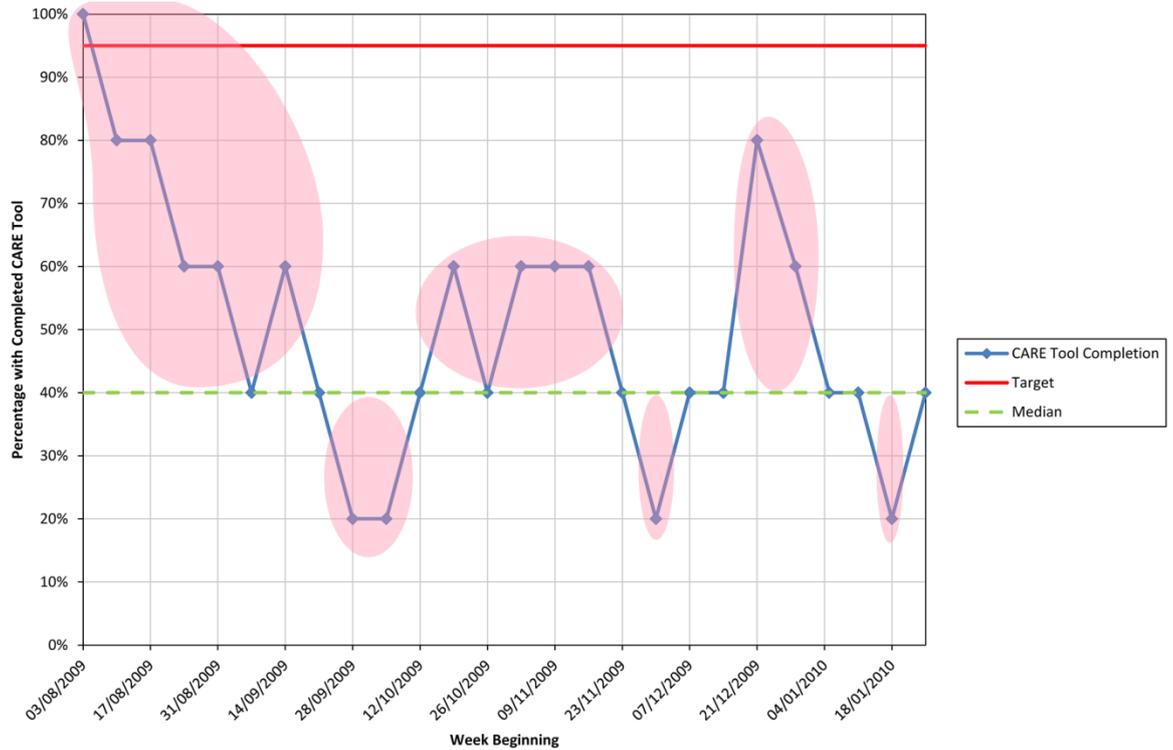


Figure 21 August 2009 to January 2010 Run Chart (Runs Highlighted)

Figure 21 shows that there are 6 runs on the CARE project run chart. As this falls within our calculated limits no special cause variation is detected using this rule.

Over this period there was no special cause variation detected using any of the run chart rules.

7.1.2 CARE Tool Completion by Staff Type

At the end of the 6 month period an assessment was made of rates of CARE tool completion by the different grades of staff within the department (See Figure 22 and Table 17).

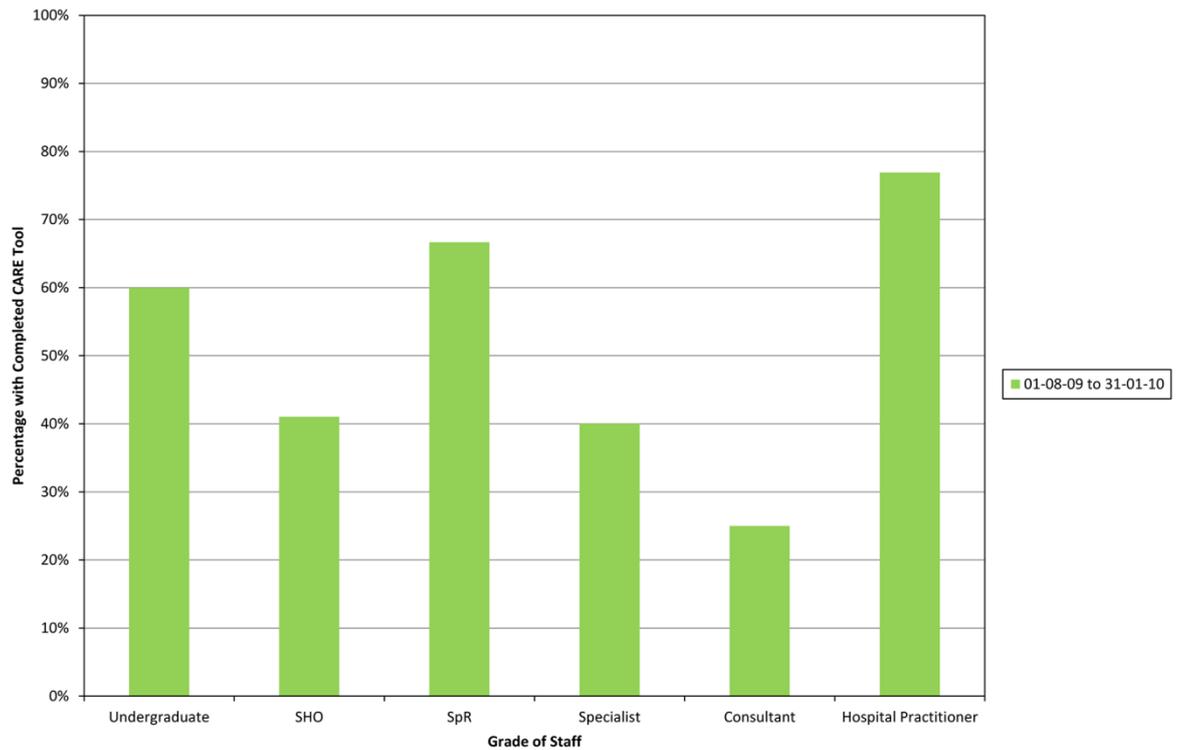


Figure 22 August 2009 to January 2010 Performance by Grade of Staff

Table 17 August 2009 to January 2010 Performance by Grade of Staff

Grade of Staff	No. of Patients Inc. in Monitoring	% of Total No. of Patients	No. of Patients with Completed CARE Tool	% of Patients with Completed CARE Tool
Undergraduate	5	4%	3	60%
SHO	39	30%	16	41%
SpR	21	16%	14	67%
Specialist	15	12%	6	40%
Consultant	24	18%	6	25%
Hospital Practitioner	26	20%	20	77%

It is concerning for two reasons that the undergraduates scored significantly less than 100%. Firstly, the behaviours of this group are the most tightly monitored and controlled so should be the easiest to change. Secondly, it is crucial that good habits in relation to caries risk assessment and prevention planning are established as early as possible in clinician's careers. The issues relating to SHO performance had already been identified on the run chart. Specialists and Consultants showed particular need for improvement, and would require targeted interventions.

7.1.3 CARE Tool Completion by Clinic Type

At the end of the 6 month period an assessment was made of rates of CARE tool completion by the different types of clinic within the department (See Figure 23 and Table 18).

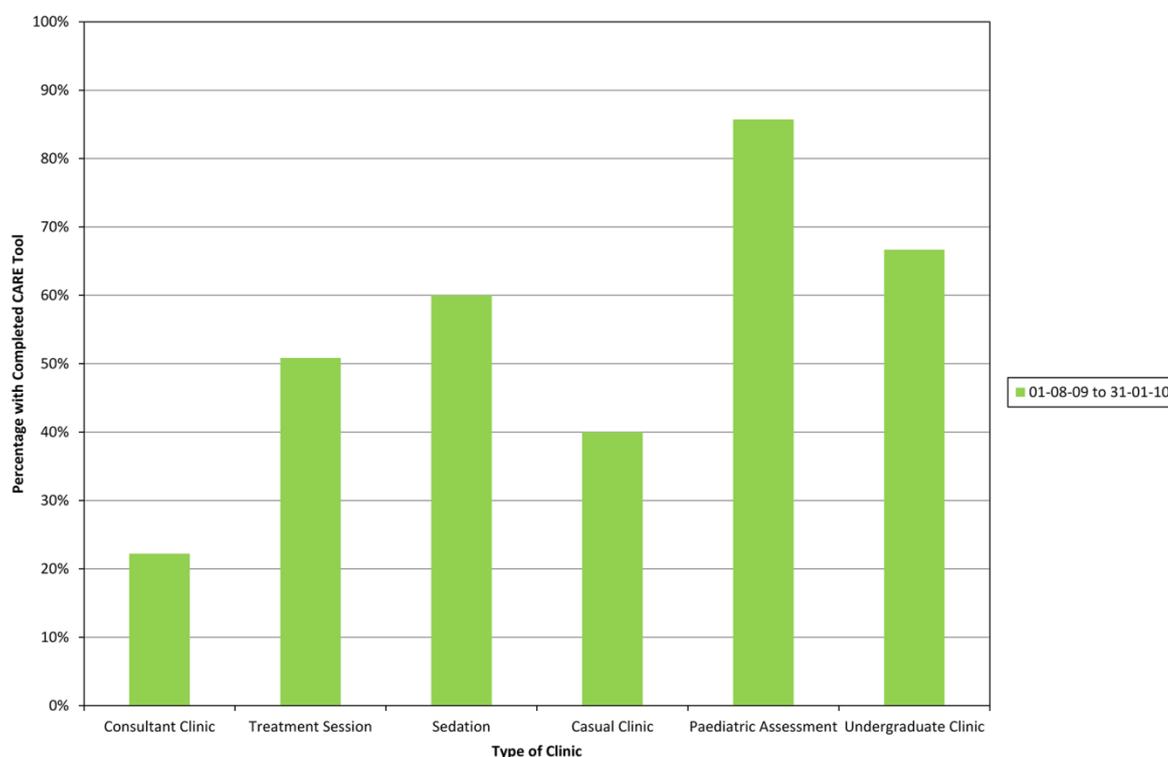


Figure 23 August 2009 to January 2010 Performance by Clinic Type

Table 18 August 2009 to January 2010 Performance by Clinic Type

Type of Clinic	No. of Patients Inc. in Monitoring	% of Total No. of Patients	No. of Patients with Completed CARE Tool	% of Patients with Completed CARE Tool
Consultant Clinic	27	21%	6	22%
Treatment Session	59	45%	30	51%
Sedation	5	4%	3	60%
Casual Clinic	15	12%	6	40%
Paediatric Assessment	21	16%	18	86%
Undergraduate Clinic	3	2%	2	67%

The immediate concern from these results was the low level of CARE tool completion on consultant clinics. As these are primarily new patient clinics, this should be the ideal time to complete a CARE tool; when treatment plans are

determined. Also if patients have a CARE tool completed at this point, when they attend at subsequent visits, i.e. a treatment clinic, a CARE tool will not be required to be completed at that point to ensure compliance; leading to overall improved performance.

7.1.4 Barriers Identified

1. A specific induction to the CARE project for the new intake of SHOs was not carried out, as they had all attended the CARE launch presentation on the 1st of August. However, it became apparent that they were not fully aware of the CARE project and their participation in it.
2. Following introduction of the new data sampling system, it rapidly became apparent that it had introduced a significant delay in obtaining results.
3. The follow up preventive care for children attending for simple extractions on the GA exodontia list, was identified as an area of concern. The PCPCS was routinely being completed advising the patients GDP of a recommended preventive care plan, but at present there was no method to ensure that patients attend with their GDP to have this carried out.

7.1.5 Change Concepts

1. Active project to engage SHOs in CARE project, running an educational event with them and involving them in running of the CARE project.
2. Discuss situation with medical records manager, and agree that a nominated member of the medical records team will deal directly with AK via email to speed up retrieval of notes.
3. Begin discussion with dental public health team, regarding developing direct referral links for children attending for GA extractions into the Childsmile programme.

7.1.6 Launch Survey

7.1.6.1 Methods – Launch Survey

For the launch survey the following questions were asked of all staff present at the CARE launch event (n = 18), which included clinicians, nurses and administrators (See Table 19).

Table 19 Launch Survey Questions

Behaviour Domain	Question(s)
Knowledge	1. “The CARE Project training document is useful?”
Beliefs about Consequences	2. “The pilot project has been a benefit to patients?”
	3. “The CARE Sheet is of use in managing patients?”
	4. “The Primary Care Provider Sheet is of use in managing patients?”
	5. “The updated Trauma Stamp is of use in managing patients?”
	6. “The new CARE Sheet will be of use in managing patients?”
7. “The new CARE Project will benefit patients?”	
Motivation and Goals	8. “The pilot project has changed working in the department for the better?”
Environmental Constraints	9. “The pilot project has generated extra work for myself?”

7.1.6.2 Results – Launch Survey

Following the launch event 18 completed questionnaires (100% response rate) consisting of 9 questions were collected from the clinicians, nurses and administrators in attendance. Results from the completed surveys were collated and are given below (See Figure 24, Table 20 and Table 21).

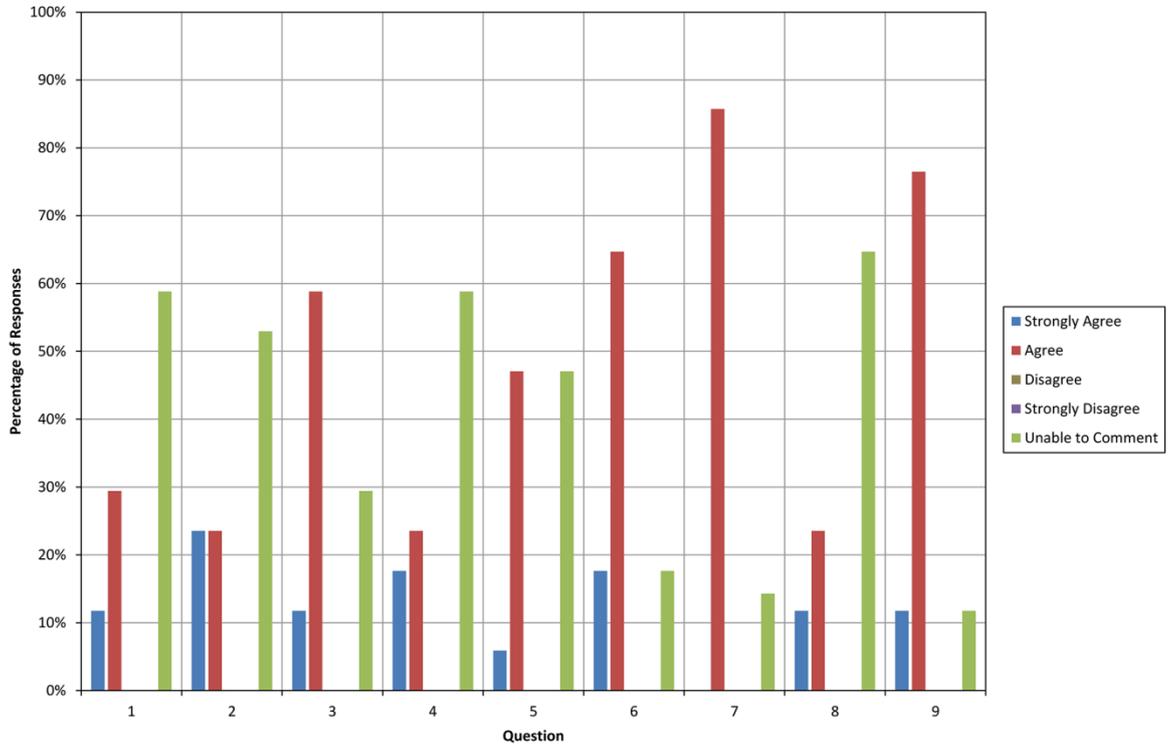


Figure 24 Responses to Launch Survey Questionnaire

Table 20 Results from Launch Survey Questionnaire

Question	Behaviour Domain	Responses (Percentage of Responses)				
		Strongly Agree	Agree	Disagree	Strongly Disagree	Unable to Comment
1 The CARE Project training document is useful?	Knowledge	2 (12%)	5 (29%)	0 (0%)	0 (0%)	10 (59%)
2 The pilot project has been a benefit to patients?	Beliefs about Consequences	4 (24%)	4 (24%)	0 (0%)	0 (0%)	9 (53%)
3 The CARE Sheet is of use in managing patients?		2 (12%)	10 (59%)	0 (0%)	0 (0%)	5 (29%)
4 The Primary Care Provider Sheet is of use in managing patients?		3 (18%)	4 (24%)	0 (0%)	0 (0%)	10 (59%)
5 The updated Trauma Stamp is of use in managing patients?		1 (6%)	8 (47%)	0 (0%)	0 (0%)	8 (47%)
6 The new CARE Sheet will be of use in managing patients?		3 (18%)	11 (65%)	0 (0%)	0 (0%)	3 (18%)
7 The new CARE Project will benefit patients?		0 (0%)	6 (86%)	0 (0%)	0 (0%)	1 (14%)
8 The pilot project has changed working in the department for the better?	Motivation and Goals	2 (12%)	4 (24%)	0 (0%)	0 (0%)	11 (65%)
9 The pilot project has generated extra work for myself?	Environmental Constraints	2 (12%)	13 (76%)	0 (0%)	0 (0%)	2 (12%)

Table 21 Respondent Comments to Launch Survey Questionnaire

Question	Comment(s)
1	Unable to comment - not had training. For new staff it would be worthwhile including a section on what the options/guidelines are in relation to filling in each prevention plan box, i.e. categories of toothpaste strength/supplements levels etc. We are not all fluent in SIGN guidelines. Have not seen this document. All nurses should have access to this document also.
2	Yorkhill has not been affected yet.
3	<i>(no comments)</i>
4	<i>(no comments)</i>
5	Not really used at Yorkhill.
6	I think it will be very useful to have a standard treatment plan.
7	<i>(no comments)</i>
8	Unable to comment - new to department. Yorkhill has not been affected yet.
9	More photocopying. Only in paper work. Yorkhill has not been affected yet.
General	Good for a set bullet points to follow for caries risk

7.1.6.3 Discussion – Launch Survey

Whilst the response rate was 100%, this was limited to those who did attend the launch event. The majority of clinicians and nurses from the department did attend, though a few were unable as they had conflicting commitments. Although the full medical records team was invited, their representation was limited to the medical records manager. This demonstrates the difficulty in obtaining the full participation of teams when individuals are already under pressure from other work commitments.

Overall responses from those respondents who did indicate an opinion were positive, there was a significant majority where they either did not respond or indicated “unable to comment”. For question 1, in relation to the knowledge domain, only just over a third of the 18 completed questionnaires gave a positive response; indicating a deficiency in this area, reinforced by the comments.

Questions 2-7 all related to beliefs about consequences and here the opinions expressed concern regarding the CARE project interventions was mixed. For

those relating to past or current interventions (questions 4-5), a majority of around 50% were unable to comment about their usefulness; except in relation to the CARE sheet (question 3) where 59% agreed it was useful. In relation to future interventions (questions 6 - “The new CARE Sheet will be of use in managing patients?” and 7 - “The new CARE Project will benefit patients?”), the majority of responses were either “strongly agree” or “agree”; an encouraging indication of staff believing that future changes will be positive and reinforced by the comments. However, particularly for question 7, a large group of respondents gave no answer at all. This lack of response, coupled with the proportion of an “unable to comment” response in the other questions, give a potential signal that members of the team remained unconvinced about the project.

Question 8 was intended to gauge the motivation of the team in relation to the project. Again it appears that there was one group who were positive and engaged, whilst there was another group, who were not negative about the project, but neither were they actively engaged at this point. Finally, the pressure of the CARE project on staff workloads was always a concern. Question 9 and the related comments; suggest that whilst staff did report some increased workload, this was not considered excessive.

7.1.7 2009-10 With and Without CARE Tool Survey

7.1.7.1 Methods – 2009-10 With and Without CARE Tool Survey

In January 2010, the “with and without CARE Tool survey” was repeated using the same methodology as in January 2009 (See 3.3.1 Methods - 2008-09 With and Without CARE Tool Survey, Page 95). This was to allow continued monitoring of the impact the use of the CARE tools had on preventive care delivery. For this audit the 20 patients for each group was selected from patients in October 2009.

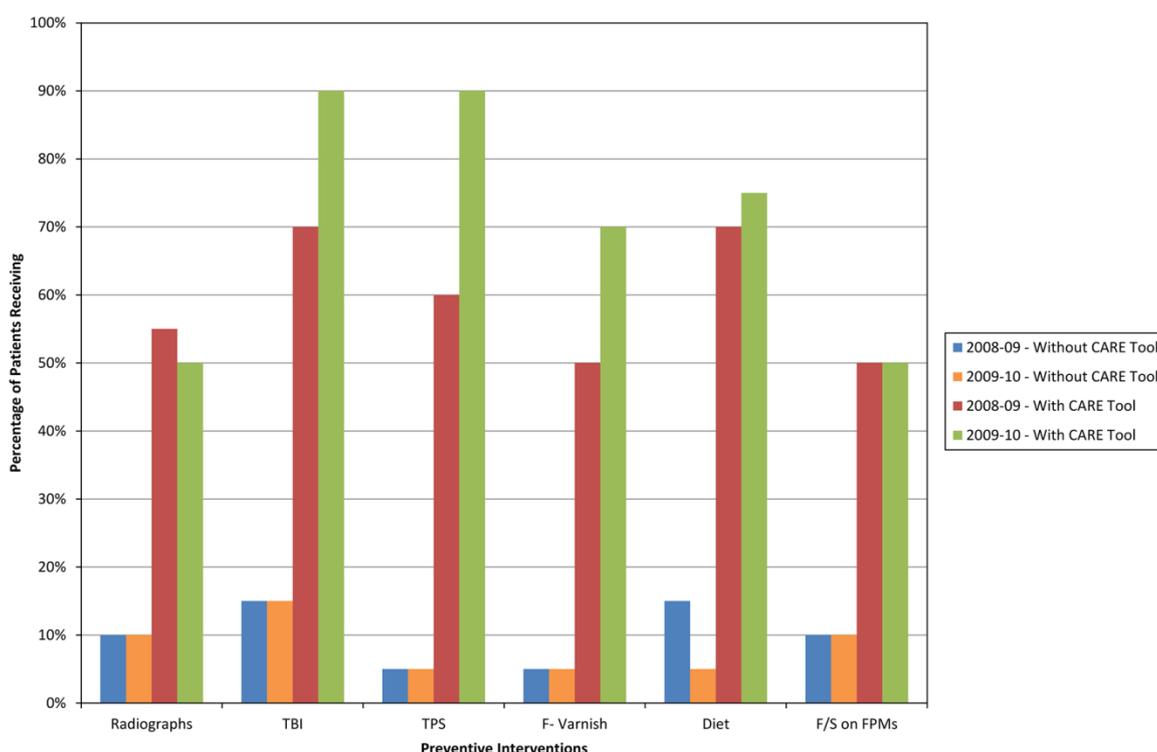
7.1.7.2 Results – 2009-10 With and Without CARE Tool Survey

For this assessment 40 case notes of patients seen in October 2009 were reviewed four months later in January 2010. These case notes were grouped into two; 20 case notes of patients known to have a CARE sheet completed and 20 case notes of patients known not to have a CARE sheet (See Table 22).

Table 22 2009-10 With and without CARE Tool Survey Results

Preventive Intervention	Percentage of Patients Receiving	
	With CARE Tool Completed	Without CARE Tool Completed
Radiographs	10%	50%
TBI	15%	90%
TPS	5%	90%
F ⁻ Varnish	5%	70%
Diet	5%	75%
F/S on FPMs	10%	50%

Figure 25 shows the above results plotted along with the results from the 2008-09 With and Without CARE tool survey for comparison.

**Figure 25 2008-10 With and without CARE Tool Survey Results**

7.1.7.3 Discussion – 2009-10 With and Without CARE Tool Survey

As with the 2008-09 With and Without CARE tool audit no statistical analysis was performed. However, these results continue to show a marked difference in documentation of prevention delivery between those patients with a CARE tool and those without. Encouragingly for those patients with a completed CARE tool documentation of preventive interventions appears to have improved (TBI, TPS, F⁻ Varnish) or effectively remained the same (Radiographs, Diet, F/S on FPMs) between the 2008-09 and 2009-10 surveys. Whilst for patient without a

completed CARE tool, levels of documentation of preventive care delivery has remained consistent in all categories, barring diet advice.

As discussed in relation to the 2008-09 with and without CARE Tool Survey, selection bias between the two groups is present, due to the type of patient who does not get a CARE sheet completed, also likely being a type of patient who does not get many preventive care interventions documented.

As these results continued to show a large benefit to the care of patients who did get a CARE sheet completed, they were highlighted to staff at the next clinical governance meeting to reinforce motivation (See 7.2.6 Dissemination of Results, Page 139).

7.1.8 Dissemination of Results

On the 1st of August 2009 the CARE project was formally launched at a special lunch time event. Here all members of the paediatric dental team were invited, including; clinicians, nurses, administration staff and managers. The session started with a free buffet lunch, funded by the department endowment, followed by a brief presentation detailing the success of the pilot project and the aims and methods to be employed by the CARE project. Before leaving the attendees were asked to complete a brief questionnaire asking them to detail their experiences with the pilot project, both positive and negative.

In September 2009 the results from the pilot project were presented at the annual scientific meeting of the British Society of Paediatric Dentistry (BSPD) in the audit prize category. This was an opportunity to raise the profile of the QI methods being employed in this project. However, from the questioning following the presentation, it was evident that many did not yet appreciate how this project differed from conventional audit projects.

To further enhance awareness of the CARE project locally, results from the pilot along with details of the CARE project were presented at the October 2009 joint study day between the department of paediatric dentistry and the Glasgow community dental service (CDS). Many members of the CDS are outreach tutors for the undergraduate training at Glasgow and this group also treats significant

numbers of children, and so it was felt that this was an important group to be aware of the aims of the CARE project.

Along with these presentations, results were widely disseminated via both regular departmental emails and frequent updating of the departmental quality improvement notice board, which both ran for the full duration of the project. The improvement notice board was established in prominent location in the corridor, immediately adjacent to the main door to the clinic. Here the aim statement for the CARE project was displayed, along with the run chart and most recent results from the prevention surveys. Updating of the notice board occurred approximately every 6 weeks, which generally coincided with the distribution of the departmental email. The departmental email focused on concisely summarising the progress of the project, highlighting any immediate issues and would have the most recent run chart attached. A full summary of how information was disseminated over this period is given in Table 23.

Table 23 Dissemination Methods August 2009 to January 2010

Date	Event (Method of Presentation)	Presenter	Topics Covered
August 2009	CARE Launch (Oral)	AK	Summary of Pilot Project Use of CARE Toolkit New data sampling methodology Aims of CARE project
September 2009	BSPD (Oral)	AK	Summary of Pilot Project
October 2009	CDS Study Day (Oral)	AK CC SHO	Summary of Pilot Project Use of CARE Toolkit Aims of CARE project
Every 6 weeks	Departmental email (Email)	AK	Progress of CARE project
Every 6 weeks	Departmental QI notice board		Progress of CARE project

7.1.9 Knowledge Gained

With the initiation of the new data sampling system it became apparent that retrieval of notes from medical records was an issue that was leading to significant delay in obtaining results. To address this barrier, a meeting was organised with the medical records manager to determine a course of action to negate this. It was agreed that an identified member of the health records team would action the requests for notes within 48 hours. This would only apply to case notes that had returned to central filing. Difficulty remained with the significant proportion of notes which did not immediately return to filing following a clinic. Often they would go to clinician's offices, secretaries or remote sites like Yorkhill. To manage this issue the lead investigator kept a log of all outstanding notes for examination. If any case notes did not return to central filing after 4 weeks, they would personally attempt to locate them; ensuring results in a timely fashion.

It was intended that having the SHOs attend the CARE project launch event on the 1st of August would be sufficient training. The subsequent experience in this period was that, because the launch event was not specifically tailored to the SHOs educational needs, they were left with deficiencies in their knowledge. This led to the development of non-compliant behaviours in relation to the CARE project. Once identified, attempts were made to address these deficiencies; however, this was found to be considerably more difficult to change behaviours once established.

Children who have had a dental GA constitute an extremely high risk group for development of further dental caries. Ensuring delivery of preventive care to children who have required a GA for dental extractions had been identified during the pilot project as an important target area. Whilst the PCPCS does include a recommended preventive plan, which is sent back to the referring GDP; there is no system to ensure this is carried out. Therefore, discussions began in this period with colleagues in the dental public health team, about developing a formal pathway for these children within the Childsmile programme.

Based on the experiences in this period two areas were to be targeted in the next 6 months. These included; highlighting the importance of completing a CARE tool to the undergraduate tutors, ensuring a thorough induction into the CARE project for the next rotation of SHOs and investigating the poor completion rates on consultant clinics.

7.2 February 2010 to July 2010

A summary of the barrier identified and changed concepts introduced in this period are given below (See Table 24).

Table 24 Barriers and Change Concepts February 2010 to July 2010

Barrier	Behaviour Domain	Change Concept	Date Implemented
1. Not all student tutors aware of CARE tools.	Knowledge	1. Email sent to all student tutors.	February 2010
2. Ensure SHO involvement from start of rotation.	Knowledge and Social Influences	2. CARE project as part of SHO induction.	February 2010
3. Lack of consistent placement of CARE sheet in new patient notes.	Environmental Constraints	3. Nursing staff begin CARE sheet by taking heights and weights of new patients.	March 2010

7.2.1 Run Chart

The run chart for this period with the introduction of change concepts from Table 24 annotated, is seen below (See Figure 26).

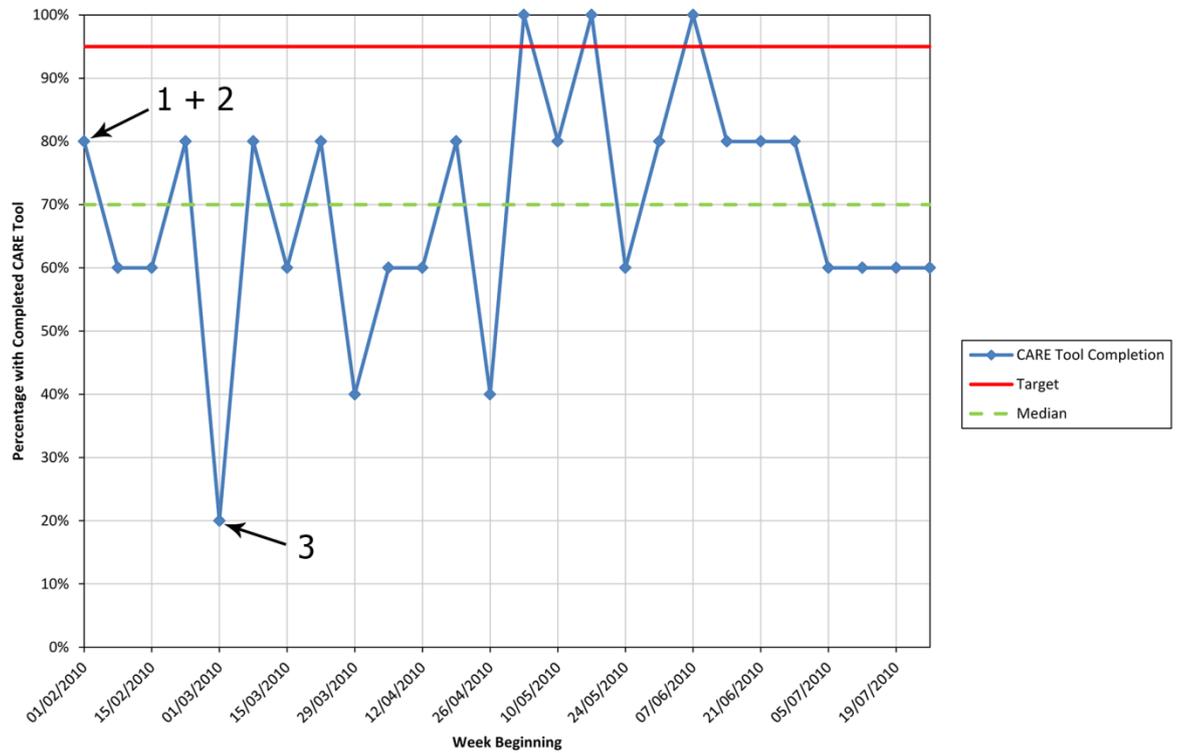


Figure 26 February 2010 to July 2010 Run Chart
Annotated numbers relate to implementation of Change Concepts as list on Table 24.

From Figure 26 the median has increased to 70% for this time period compared to 40% for the previous 6 months, whilst the number of useful observations was counted as being 26. This value was then used to calculate a lower and upper value for the number of expected runs for the CARE project run chart.

$$\text{Lower Limit for Expected Runs} = \frac{26}{3} = 8.67 \text{ (Rounded Down} = 8)$$

$$\text{Upper Limit for Expected Runs} = \frac{2 \times 26}{3} = 17.33 \text{ (Rounded Up} = 18)$$

The number of runs on the CARE project run chart was then found (See Figure 27).

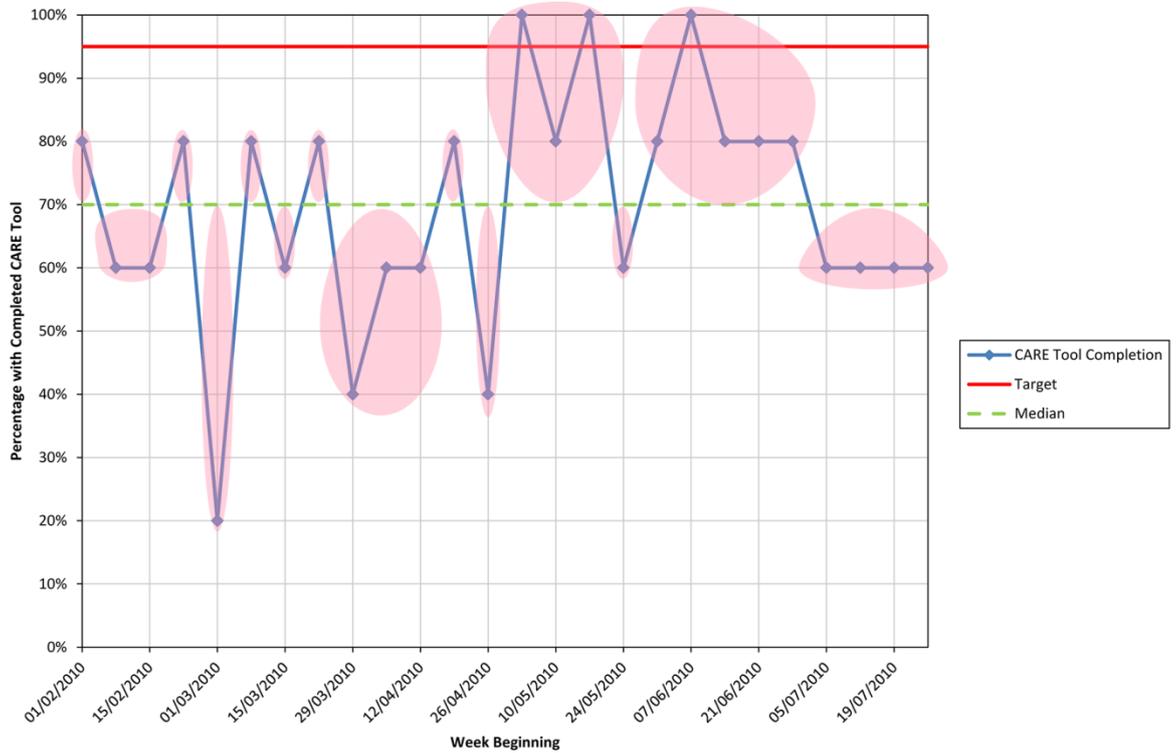


Figure 27 February 2010 to July 2010 Run Chart (Runs Highlighted)

Figure 27 shows that there are 14 runs on the CARE project run chart. As this falls within our calculated limits no special cause variation is detected using this rule.

Over this period there was no special cause variation detected using any of the run chart rules.

7.2.2 CARE Tool Completion by Staff Type

At the end of the 6 month period an assessment was made of rates of CARE tool completion by the different grades of staff within the department (See Figure 28 and Table 25).

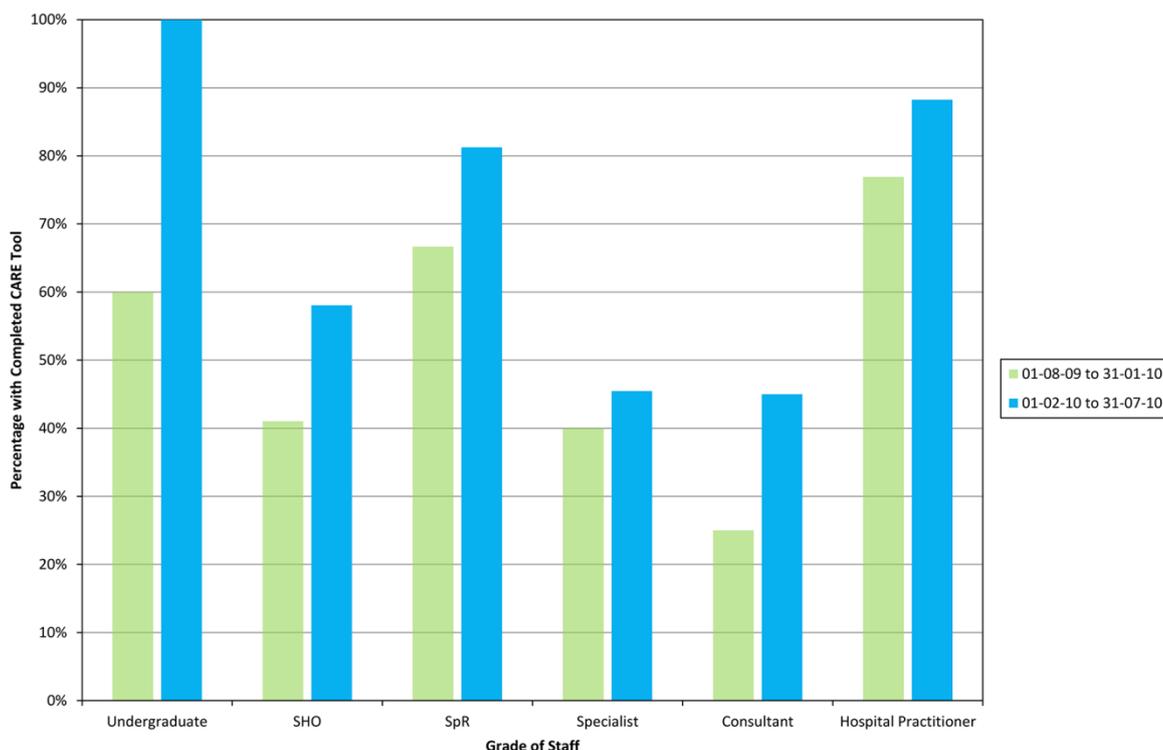


Figure 28 February 2010 to July 2010 Performance by Grade of Staff

Table 25 February 2010 to July 2010 Performance by Grade of Staff

Grade of Staff	No. of Patients Inc. in Monitoring	% of Total No. of Patients	No. of Patients with Completed CARE Tool	% of Patients with Completed CARE Tool
Undergraduate	2	2%	2	100%
SHO	31	24%	18	58%
SpR	32	25%	26	81%
Specialist	11	8%	5	45%
Consultant	20	15%	9	45%
Hospital Practitioner	34	26%	30	88%

It was reassuring to see that the completion of a CARE tool on the undergraduate clinics improved to 100% over this period compared to 60% for the first 6 months. The sample of undergraduate patients is very small, so this result must be treated with caution. The SpR and Hospital Practitioner groups both recorded a level of performance of greater than 80% for this period. This level of performance, whilst still short of our overall 95% target, is highly promising and would ideally be replicated across all the staff groups. Overall, improved performance was seen in all staff groups, an encouraging finding; suggesting that changes were having a positive impact. However, significant scope for further improvement remains, particularly in the specialist and consultant groups, who

despite showing improved performance in this period, continue to display a level of performance under 50%.

7.2.3 CARE Tool Completion by Clinic Type

At the end of the 6 month period an assessment was made of rates of CARE tool completion by the different types of clinic within the department (See Figure 29 and Table 26).

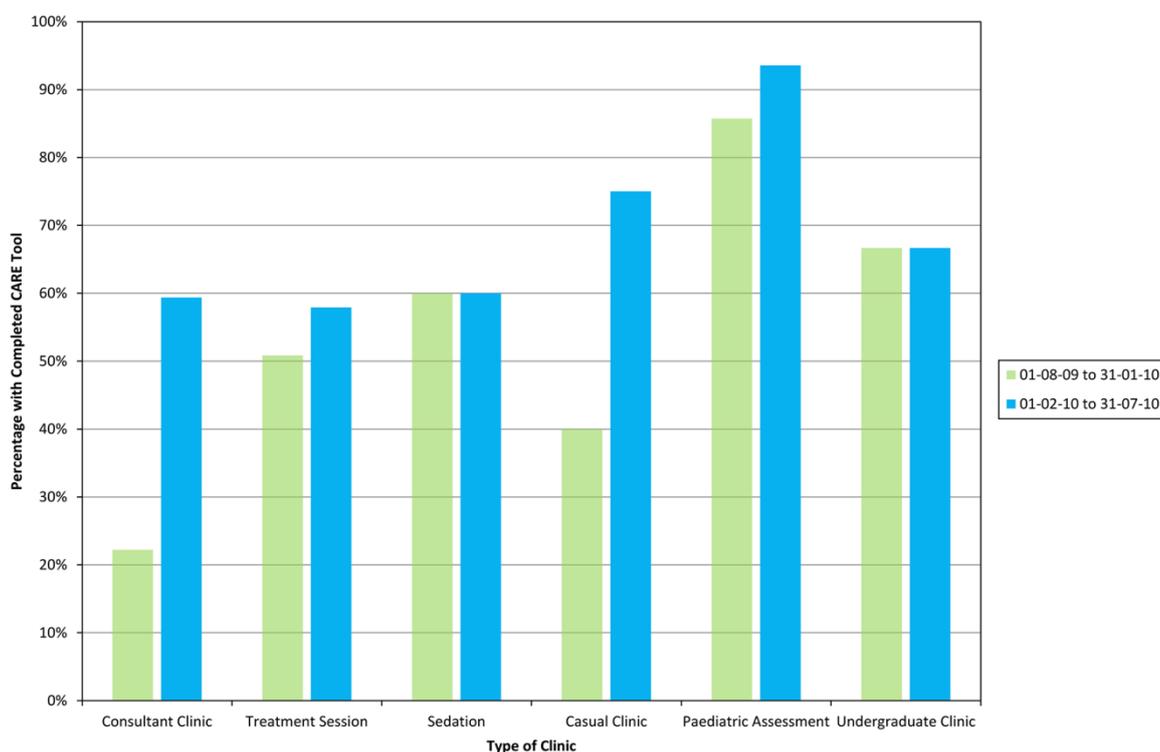


Figure 29 February 2010 to July 2010 Performance by Clinic Type

Table 26 February 2010 to July 2010 Performance by Clinic Type

Type of Clinic	No. of Patients Inc. in Monitoring	% of Total No. of Patients	No. of Patients with Completed CARE Tool	% of Patients with Completed CARE Tool
Consultant Clinic	32	25%	19	59%
Treatment Session	38	29%	22	58%
Sedation	10	8%	6	60%
Casual Clinic	16	12%	12	75%
Paediatric Assessment	31	24%	29	94%
Undergraduate Clinic	3	2%	2	67%

When compared to the previous 6 month period, large improvements are seen on both the consultant clinics and casual clinic. It is the SHO grade clinicians that primarily staff the casual clinics, and so it was an encouraging sign that the efforts relating to SHO education was having an impact. The consultant clinic is also staffed by SHOs, along with SpRs and Consultants, so the improved SHO education will have been beneficial to the performance of this clinic. However, having the nursing staff initiate completion of a CARE sheet by taking heights and weights had a positive impact on this clinic as well.

The undergraduate clinic results from this period appear to conflict with the results from the staff results; showing that 100% of patients seen by an undergraduate had a completed CARE tool. The one non-compliant patient on the undergraduate clinic was a patient who did not have their treatment carried out by an undergraduate for clinical reasons. This also provided anecdotal evidence of the increased likelihood of failing to undertake a desired behaviour in non-standard clinical situations.

7.2.4 Barriers Identified

1. It was identified that not all clinical tutors on the undergraduate clinics were aware of the need to complete a CARE tool.
2. SHO education and involvement from the beginning of their rotation.
3. Whilst CARE sheets were available on the clinic, the expectation was they were going to be placed in the case notes by medical records team; unfortunately, this was not being routinely done. We found that there was a high level of staff turnover in medical records, and whilst we could get the agreement of medical records team to put CARE sheets into the notes, these individuals often subsequently moved on to other tasks. Also they were often running out of CARE sheet supplies, and because of these staff changes, the new person did not know who to contact to request more.

7.2.5 Change Concepts

1. Email sent to all clinical tutors detailing the reasoning behind the CARE tools; particularly highlighting the educational importance for the students.
2. CARE project added as a standing item on the SHO induction programme, and all SHOs invited to participate in undertaking elements of CARE project monitoring or develop their own related projects on arrival in the department.
3. Nursing staff agreed to take on responsibility of initiating the completion of a CARE sheet for new patients, by placing a patient label on the sheet and taking the patient's height and weight on entry to the department. This initiated CARE sheet would then be passed to the clinician at the start of the consultation.

7.2.6 Dissemination of Results

At the March departmental clinical governance meeting, the progress of the CARE project to date was presented, along with the identified barriers and changes which had been implemented. Following the presentation a brief discussion of the barriers and changes was held amongst the clinicians and nursing staff present at the meeting; the consensus was that progress was being made and that the implemented changes should lead to further improvement.

In June the European Academy of Paediatric Dentistry (EAPD) held their congress, and this was a further opportunity to enhance the profile of the QI methods we were using. Based on our experience at BSPD the previous year we made efforts to highlight the cyclical and on-going nature of the CARE project, when once again it was presented in the audit prize category. We also shared some of our main learning points from the project so far in relation to staff involvement, and the measurement and development of successful systems of care.

At the same congress a separate presentation was also made of additional results for an assessment which looked at the subsequent impact that CARE tools were having on the documentation of preventive care.

A summary of how information was disseminated over this period is given in Table 27.

Table 27 Dissemination Methods February 2010 to July 2010

Date	Event (Method of Presentation)	Presenter	Topics Covered
March '10	Clinical governance (Oral)	AK	Progress of CARE project Barriers identified and changes implemented
June '10	EAPD (Oral)	AK	Progress of CARE project QI Methodology Barriers identified
June '10	EAPD (Poster)	CC	Impact of CARE project on preventive care
Every 6 weeks	Departmental email (Email)	AK	Progress of CARE project
Every 6 weeks	Departmental QI notice board		Progress of CARE project

7.2.7 Knowledge Gained

The three interventions initiated over this period appeared to have an overall positive impact on performance. This positive impact is reflected in the median on the run chart for this period being 70% (See Figure 26, Page 134). From the run chart a delay of approximately 2 months, is seen between initiation of the height and weight intervention (Change Concept 3), and the appearance of what appears to be an improved level of performance from May onwards. Having a delay such as this, between initiation of an intervention and obtaining an improved performance, is common to QI projects.

The experience of the first 12 months of the CARE project appeared to suggest that changes in SHO staff can have a significant impact on the overall performance of the CARE project. Ensuring that the SHOs were encouraged to become actively engaged with the project from the start of their rotation,

therefore, appeared to improve their performance. This further reinforced the findings from the pilot project relating to the impact changes in SHO rotation changes appears to have on results (See 3.2 Pilot Monitoring of Caries Risk Completion, Page 94).

It was disappointing that consistent input to the project from the medical record team could not be sustained. The lack of consistent placement of the CARE sheet in new case notes was identified as particularly damaging; as an expectation had been created amongst clinical staff that it would be there. Though CARE sheets were readily available on the clinic, if the medical records team had not already placed one in the notes it led feelings of resentment amongst the clinical staff. In order to address this either medical records needed to be able to guarantee consistent inclusion in the notes, or an alternative method not involving medical records needed to be developed.

Following discussion with medical records and amongst the CARE project working group, it was decided to pursue the alternative of asking the nursing staff to start a CARE sheet on new patient clinics by taking the height and weight. Prior to the CARE project height and weight was occasionally taken as part of monitoring of patients clinical condition. During the pilot project, it was decided to include a place for height and weight information to be recorded on the CARE sheet.

The rationale for this being that if all patients had a baseline height and weight taken; this would be useful for three reasons. Firstly, should it subsequently transpire during a patient's care that their height and weight needed monitoring, an initial baseline would be available. Secondly, this information may alert the clinician to general health concerns that they may otherwise not have detected. Whilst thirdly, if this information was recorded for all patients attending the department it would provide useful demographic information about the status of the children being referred for care within the department. Unfortunately, the routine recording of this information had not been taken up, however, following discussion with the nursing staff it was agreed to begin doing so. The impact of this intervention was found to be particularly positive, as it gave nursing staff involvement in the project, along with the opportunity to develop a common risk factor approach. The information gathered by this exercise

has been subsequently been developed for further health promotion work beyond the scope of the CARE project.

By the end of this period, consultant clinics remained our priority area for improvement. All new patients are initially seen on one of these clinics and if we could achieve consistent completion of a CARE tool here, then this would eventually significantly improve results for all clinics. Whilst interventions in over 50% of patients on consultant clinics were now having a CARE tool completed, a significant proportion were not. Investigation of this identified that it was on specific consultant clinics where the non-compliance was occurring. Whilst “naming and shaming” of specific clinics not completing CARE tools was considered, it was felt that it was unlikely to have a motivational effect. Instead it was decided to engage with those clinicians who were not completing a CARE tool to identify why.

7.3 August 2010 to January 2011

A summary of the barrier identified and changed concepts introduced in this period are given below (See Table 28).

Table 28 Barriers and Change Concepts August 2010 to January 2011

Barrier	Behaviour Domain	Change Concept	Date Implemented
1. Clinician feedback identifies elements of CARE sheet hampering uptake.	Nature of the behaviour	1. Revision of CARE sheet.	October 2010
2. Supplies of PCPCS run out.	Environmental constraints	2. Liaison with management to secure new supplies.	November 2010

7.3.1 Run Chart

The run chart for this period with the introduction of change concepts from Table 28 annotated, is seen below (See Figure 30).

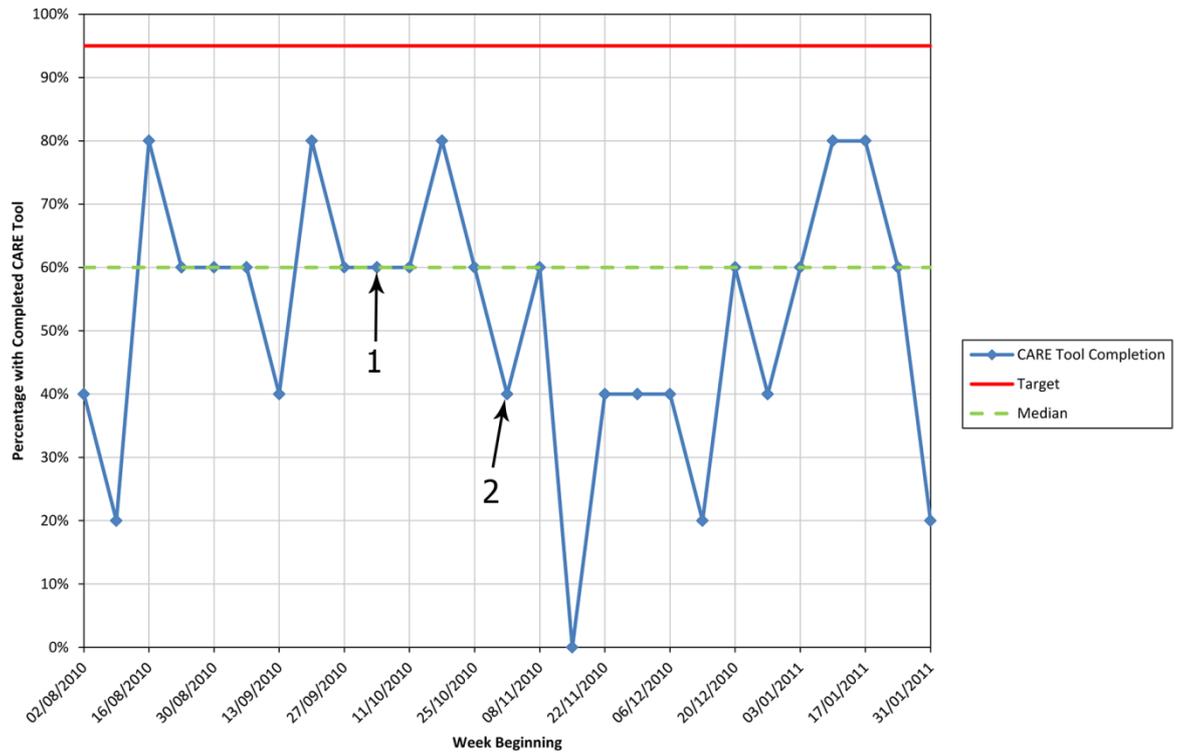


Figure 30 August 2010 to January 2011 Run Chart
Annotated numbers relate to implementation of Change Concepts as list on Table 28.

From Figure 30 the median has fallen from 70% in the previous 6 months to 60% for this time period, whilst the number of useful observations can be counted as being 16. This value was then used to calculate a lower and upper value for the number of expected runs for the CARE project run chart.

$$\text{Lower Limit for Expected Runs} = \frac{16}{3} = 5.33 \text{ (Rounded Down = 5)}$$

$$\text{Upper Limit for Expected Runs} = \frac{2 \times 16}{3} = 10.67 \text{ (Rounded Up = 11)}$$

The number of runs on the CARE project run chart was then found, as shown in Figure 31.

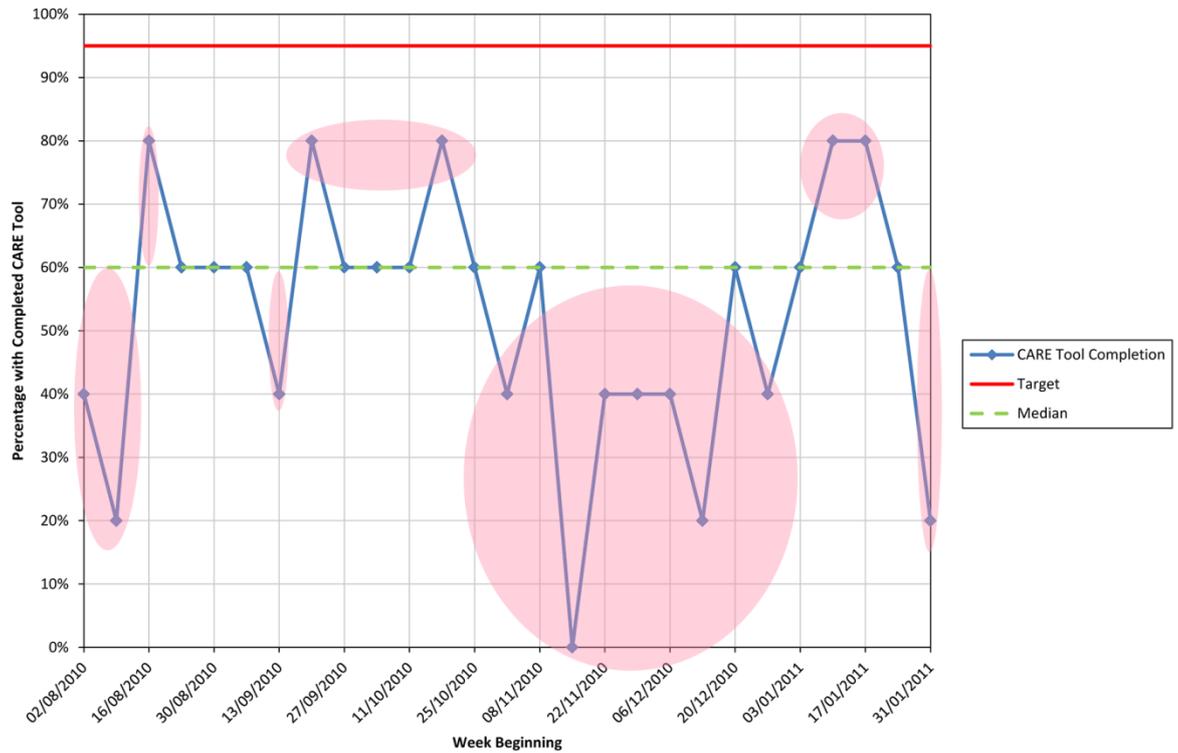


Figure 31 August 2010 to January 2011 Run Chart (Runs Highlighted)

Figure 31 shows that there are 7 runs on the CARE project run chart. As this falls within our calculated limits no special cause variation is detected using this rule.

There was a significant period between the beginning of November, which coincides with supplies of the PCPCS running out (See Figure 30 - annotation 2), till the end of January where the results predominantly shift below the 60% median. This period does not strictly confirm to the definition of a shift, as there are two points above the median at the beginning of January. However, these two points correspond to a two week period when the paediatric assessment clinic, the primary user of the PCPCS, was not running due to staff leave. Consequently, if those two data points are ignored, there are 8 data points lying below the median, signalling a downward shift in performance as highlighted below (See Figure 32).

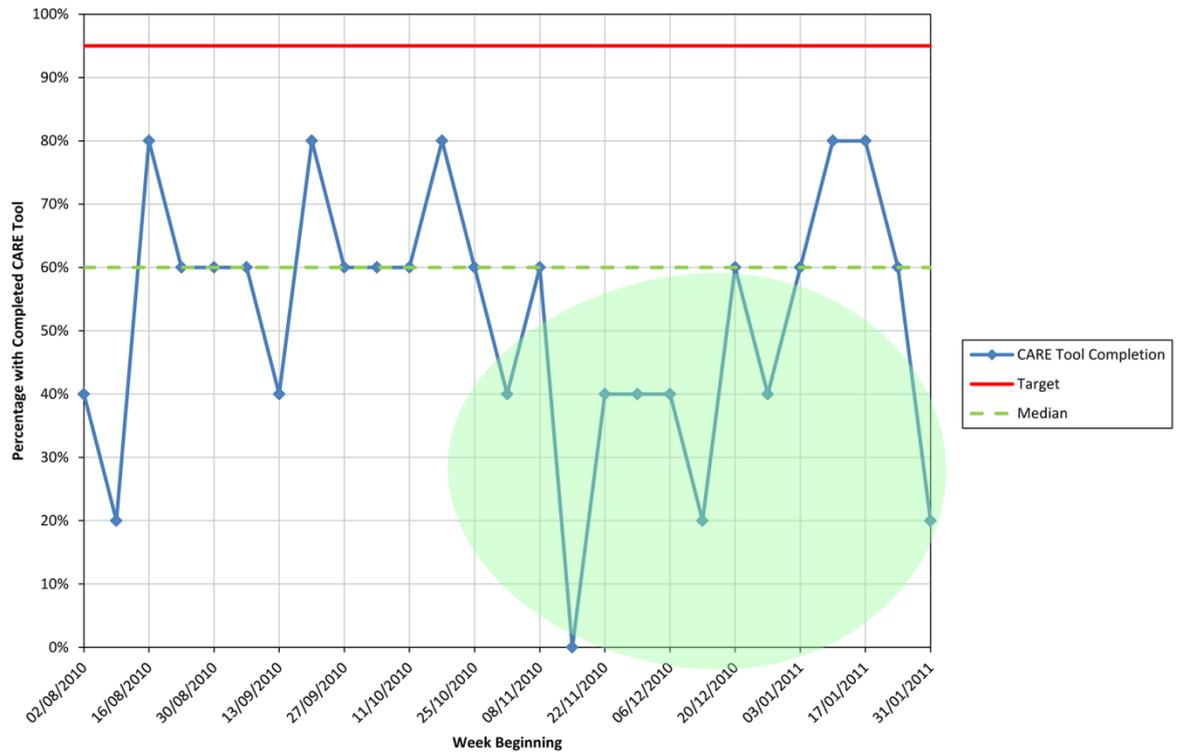


Figure 32 August 2010 to January 2011 Run Chart (Shifts Highlighted)

No other periods of special cause variation were detected using the remaining run chart rules.

7.3.2 CARE Tool Completion by Staff Type

At the end of the 6 month period an assessment was made of rates of CARE tool completion by the different grades of staff within the department (See Figure 33 and Table 29).

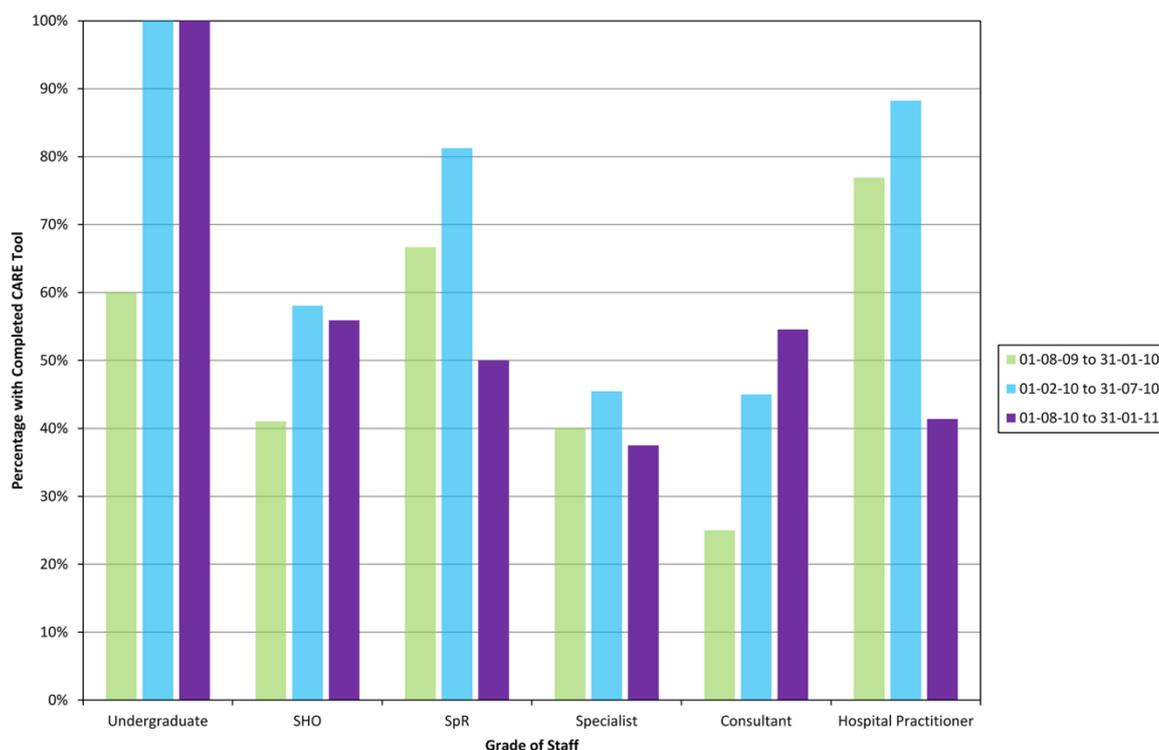


Figure 33 August 2010 to January 2011 Performance by Grade of Staff

Table 29 August 2010 to January 2011 Performance by Grade of Staff

Grade of Staff	No. of Patients Inc. in Monitoring	% of Total No. of Patients	No. of Patients with Completed CARE Tool	% of Patients with Completed CARE Tool
Undergraduate	8	6%	8	100%
SHO	34	25%	19	56%
SpR	26	19%	13	50%
Specialist	16	12%	6	38%
Consultant	22	16%	12	55%
Hospital Practitioner	29	21%	12	41%

Over this period the performance of undergraduates, SHOs and specialists remained relatively consistent with the previous period. The consultants appear to be showing a trend of continued gradual performance, suggesting that our persistence in engaging with this group was paying off. Falls were seen in both the SpR and Hospital Practitioner staff groups. For the SpRs this was identified as being due to a training need for two members of staff back from long term leave, with the need for refresher training relating to the CARE project not being anticipated, nor detected until this 6 month analysis was completed. Whilst for the Hospital Practitioners their 41% performance over this period was consistent with the loss of PCPCS supplies halfway through this 6 month period.

7.3.3 CARE Tool Completion by Clinic Type

At the end of the 6 month period an assessment was made of rates of CARE tool completion by the different types of clinic within the department (See Figure 34 and Table 30).

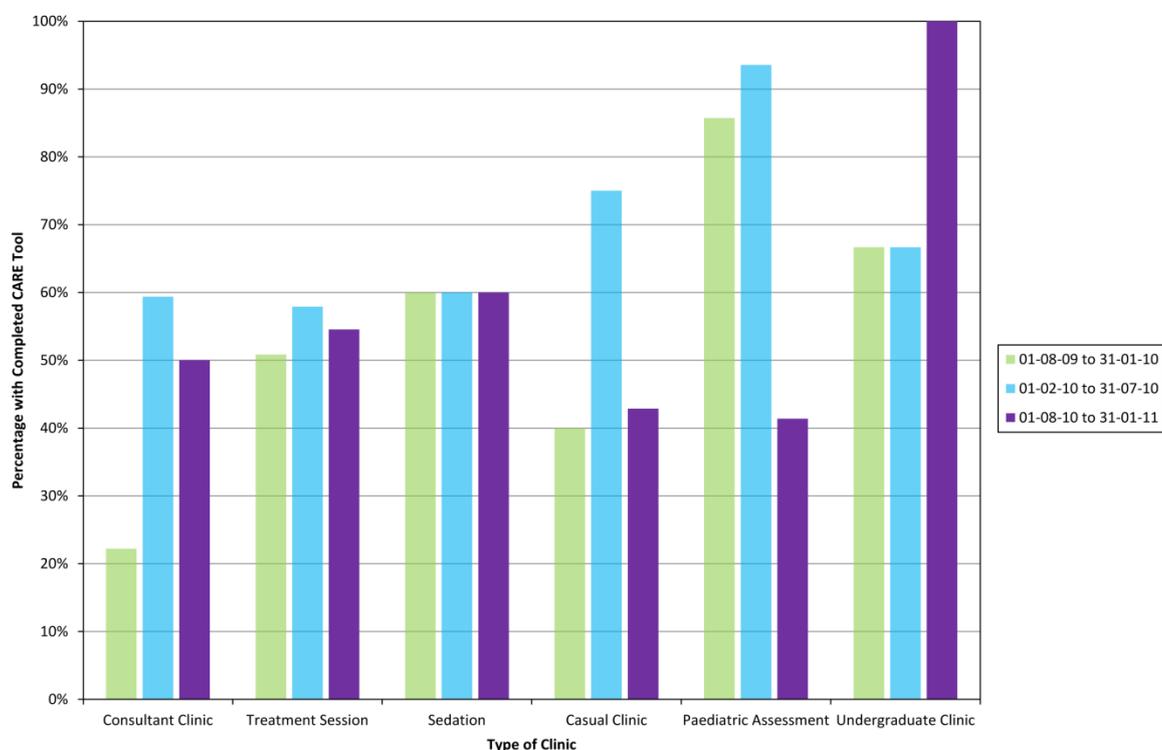


Figure 34 August 2010 to January 2011 Performance by Clinic Type

Table 30 August 2010 to January 2011 Performance by Clinic Type

Type of Clinic	No. of Patients Inc. in Monitoring	% of Total No. of Patients	No. of Patients with Completed CARE Tool	% of Patients with Completed CARE Tool
Consultant Clinic	38	28%	19	50%
Treatment Session	33	24%	18	55%
Sedation	5	4%	3	60%
Casual Clinic	21	16%	9	43%
Paediatric Assessment	29	21%	12	41%
Undergraduate Clinic	9	7%	9	100%

Across the consultant clinics, treatment sessions and sedation, there was minimal change in performance over this period compared to the previous 6 months. In this period 100% of undergraduate clinic patients had a completed

Table 31 Barrier to use of CARE Sheet and Changes made in Revision

Identified Barrier to Use	Change(s) in Revised CARE Sheet
Duplication in written notes	<ul style="list-style-type: none"> • Removed radiograph details • Made treatment plan free text
Treatment plan area too rigid and not suitable in all cases	<ul style="list-style-type: none"> • Made treatment plan free text
Ensure that treatment plan has been agreed with consultant	<ul style="list-style-type: none"> • Added areas for designating the person/grade of staff to carry out the treatment plan, along with area for consultant signature

2. Liaison with management to secure new supplies of the PCPCS.

7.3.6 Dissemination of Results

During these 6 months (Aug '10 to Jan '11) progress was made by further spreading the ethos of the CARE project out with the department into the CDS. A meeting was held in January with a group of motivated early adopters within the CDS. They had been recruited as they expressed interest in evaluating the performance of the CDS in relation to CRA and preventive care. As there was already strong links between the department and CDS with regard to undergraduate teaching, it was decided that a survey, similar to the prevention surveys carried out for the CARE project would be undertaken on the undergraduate outreach clinics. It was also felt important to evaluate how the service was performing in relation to the Scottish governments HEAT target, aiming for 60% of 3 and 4 year olds, across every SIMD category, to have fluoride varnish applied twice a year. This was to be led by members of the CDS, who would be responsible for presenting and disseminating the results within their own service.

A summary of how information was disseminated over this period is given in Table 32.

Table 32 Dissemination Methods August 2010 to January 2011

Date	Event (Method of Presentation)	Presenter	Topics Covered
January 2010	CDS Meeting (Meeting)	AK CC	Initiation of a project to evaluate caries risk and prevention completion on undergraduate clinics within GDHS and CDS. Evaluation of compliance in relation to fluoride varnish target
Every 6 weeks	Departmental email (Email)	AK	Progress of CARE project
Every 6 weeks	Departmental QI notice board		Progress of CARE project

7.3.7 Knowledge Gained

The feedback received regarding the CARE sheet was useful, as some of the changes implemented at the start of the CARE project, intended to help improve performance, were perceived as restrictive by some clinicians. For example the structured treatment plan with pre-printed defaults was reported as being restrictive, non-suitable for all patients, not giving enough space to write and not all treatment plans could be broken down into sequentially numbered lists. Changing this to a free text area was anecdotally reported as positive, as this conformed to clinicians current behaviour regarding writing treatment plans in the patients general case notes. Therefore, clinicians were happy to simply transfer the writing of the treatment plan from the general case notes to a CARE sheet.

Education and training was again identified as an important issue. This time it was the return of staff from a long period of leave. For a rapidly changing QI project, such as the CARE project, it will not be uncommon for significant changes to have occurred after 6-9 months. Therefore, it is important that staff such as this are effectively treated the same as any new staff member, with a full induction on their return to work.

Unfortunately, half way through this 6 month period a significant setback occurred regarding the loss of PCPCS supplies. This was one of the most successful elements of the CARE project, with its use well integrated into the running of the paediatric assessment clinic and not requiring the active intervention of the CARE project working group to ensure its use. When it was reported that the PCPCS supplies had run out, the working group immediately attempted to secure more supplies. However, the PCPCS is a pre-printed triplicate pad, which required to be externally ordered with special approval of management. Initially it was hoped that this could be secured without difficulty. However, by the end of this period new supplies of the PCPCS were still not secured.

7.4 February 2011 to August 2011

A summary of the barrier identified and changed concepts introduced in this period are given below (See Table 33).

Table 33 Barriers and Change Concepts February 2011 to August 2011

Barrier	Behaviour Domain	Change Concept	Date Implemented
1. Lack of knowledge in SpR and Specialist group	Knowledge	1. Education delivered to SpRs and Specialists	February 2011
2. Continued lack of PCPCS availability.	Environmental Constraints	2. New supplies of PCPCS arrive.	April 2011
3. SHOs not getting CARE sheets signed off by consultants.	Social Influences and Behavioural Regulation	3. Post clinic "wash up" introduced.	May 2011

7.4.1 Run Chart

The run chart for this period with the introduction of change concepts from Table 33 annotated, is seen below (See Figure 36).

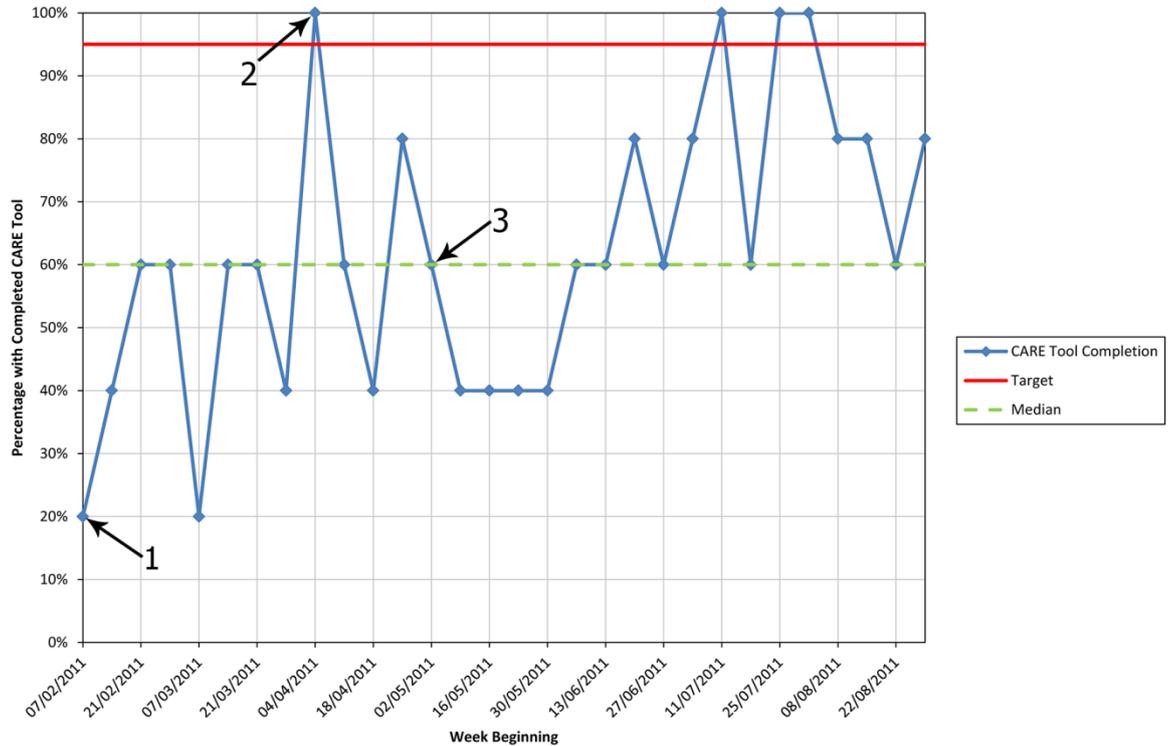


Figure 36 February 2011 to August 2011 Run Chart
Annotated numbers relate to implementation of Change Concepts as list on Table 33.

From Figure 36 the median has remained static at 60% when compared to the previous 6 months, whilst the number of useful observations was counted as being 19. This value was then used to calculate a lower and upper value for the number of expected runs for the CARE project run chart.

$$\text{Lower Limit for Expected Runs} = \frac{19}{3} = 6.33 \text{ (Rounded Down = 6)}$$

$$\text{Upper Limit for Expected Runs} = \frac{2 \times 19}{3} = 12.67 \text{ (Rounded Up = 13)}$$

The number of runs on the CARE project run chart was then found, as shown in Figure 37.

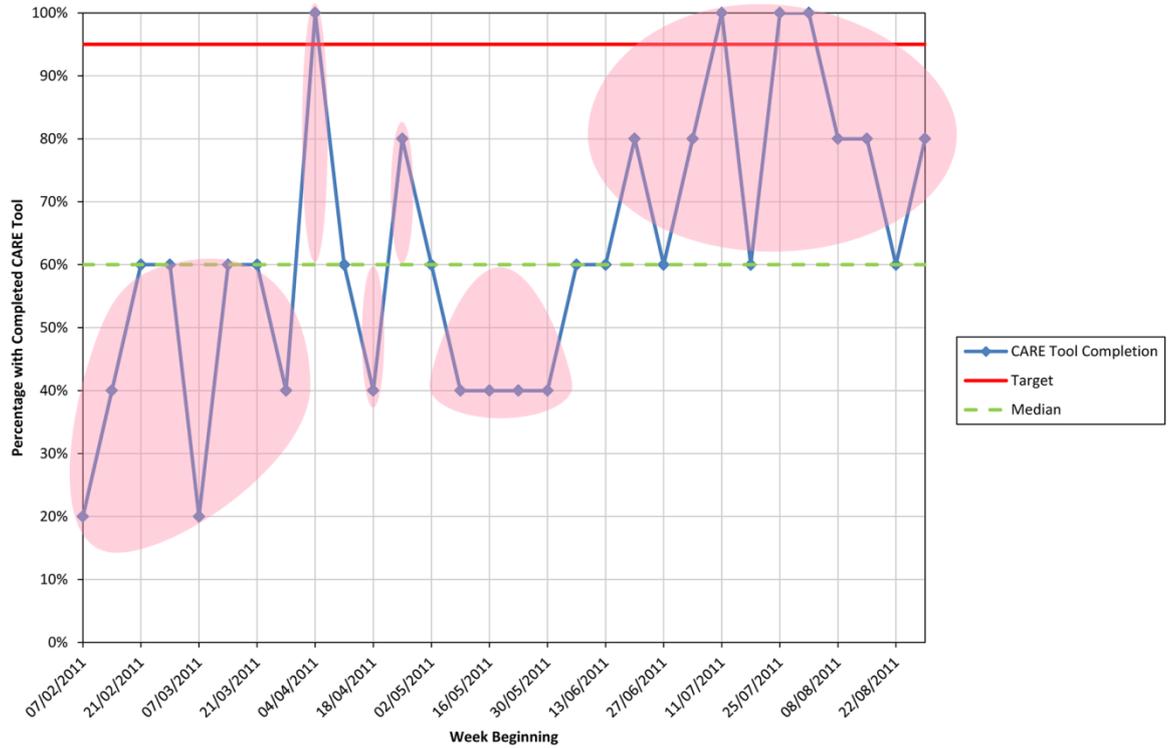


Figure 37 February 2011 to August 2011 Run Chart (Runs Highlighted)

Figure 37 shows that there are 6 runs on the CARE project run chart. As this falls within our calculated limits no special cause variation is detected using this rule.

From mid-June till the end of August, there are 8 data points lying above the median; this signalled a shift in process performance and is highlighted below (See Figure 38).

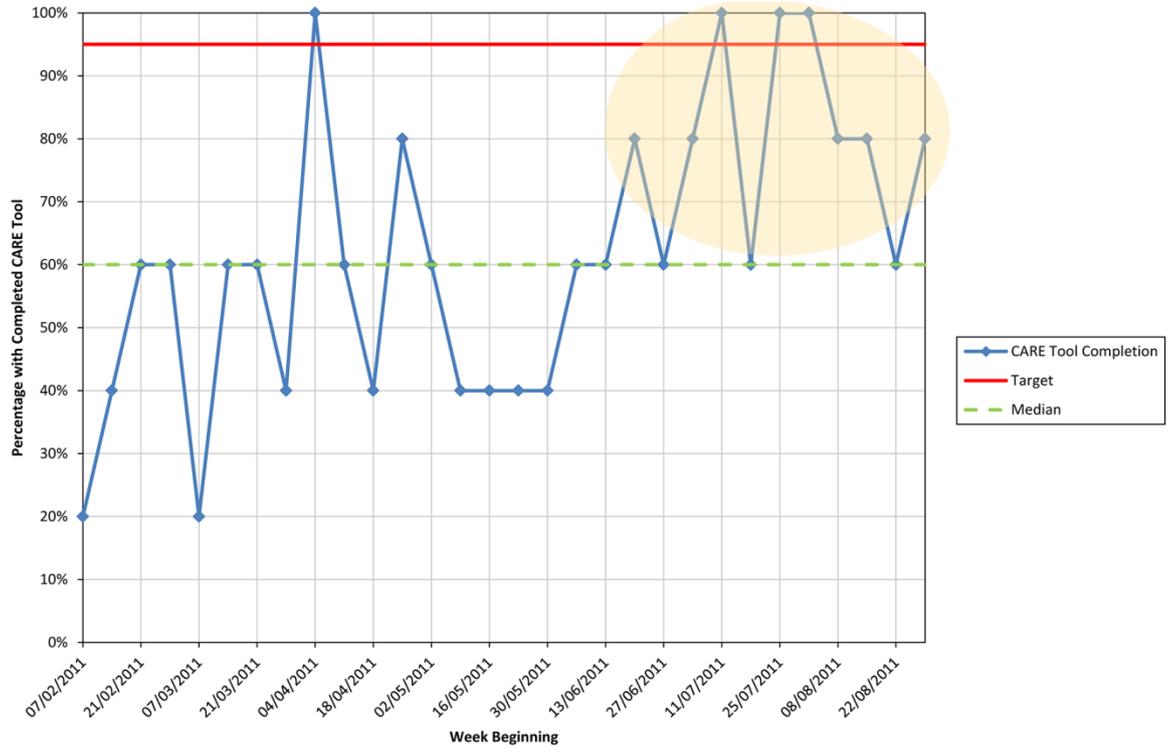


Figure 38 February 2011 to August 2011 Run Chart (Shifts Highlighted)

No other periods of special cause variation were detected using the remaining run chart rules.

7.4.2 CARE Tool Completion by Staff Type

At the end of the 7 month period an assessment was made of rates of CARE tool completion by the different grades of staff within the department (See Figure 39 and Table 34).

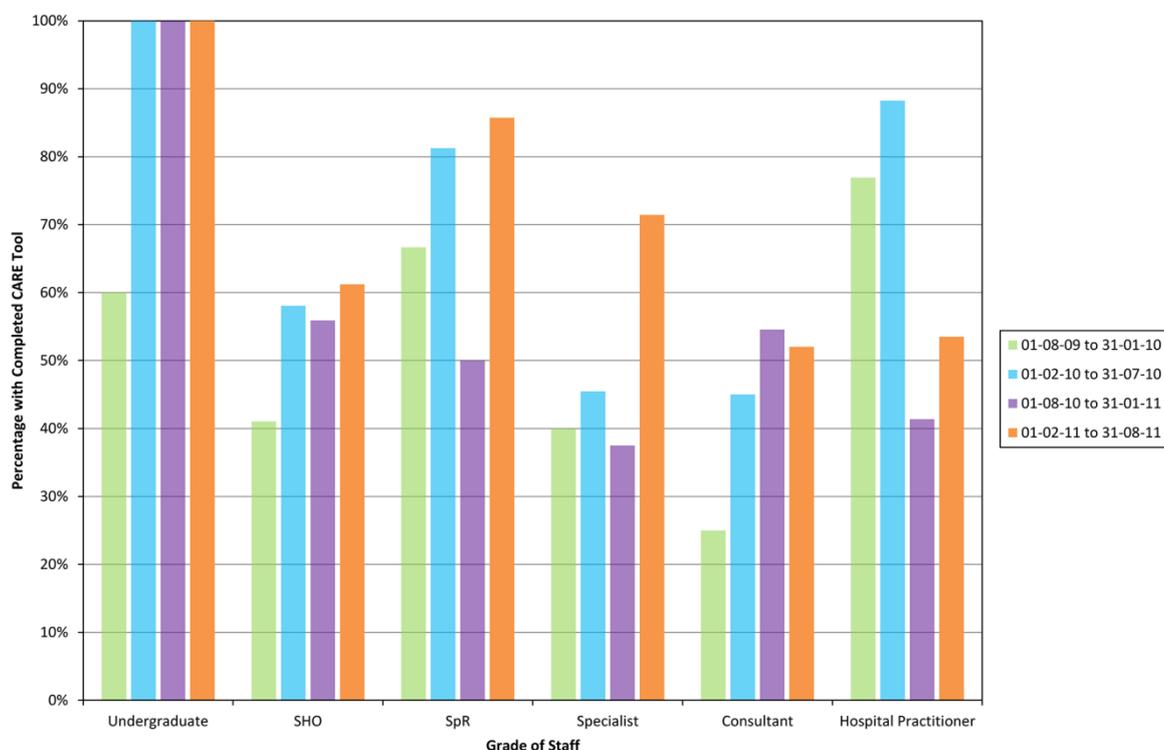


Figure 39 February 2011 to August 2011 Performance by Grade of Staff

Table 34 February 2011 to August 2011 Performance by Grade of Staff

Grade of Staff	No. of Patients Inc. in Monitoring	% of Total No. of Patients	No. of Patients with Completed CARE Tool	% of Patients with Completed CARE Tool
Undergraduate	5	3%	5	100%
SHO	49	33%	30	61%
SpR	21	14%	18	86%
Specialist	7	5%	5	71%
Consultant	25	17%	13	52%
Hospital Practitioner	43	29%	23	53%

No significant change in performance was seen in either the undergraduate, SHO or consultant groups during this period. The performance of the hospital practitioner group remained depressed, primarily due to the lack of PCPCS for the first half of this period. Large improvements in performance in both the SpR and Specialist groups are seen. For the SpR group this represents a return to the level of performance seen in the February '10 to July '10 period. Whilst for the Specialist group, this is a marked improvement in their level of performance, suggesting that the educational intervention at the start of this period was of significant benefit to this group. Disappointingly, the consultant group appears

to have plateaued at around the 50% mark. As the clinical leaders within the department, having this group perform at this level is concerning.

7.4.3 CARE Tool Completion by Clinic Type

At the end of the 7 month period an assessment was made of rates of CARE tool completion by the different types of clinic within the department (See Figure 40 and Table 35).

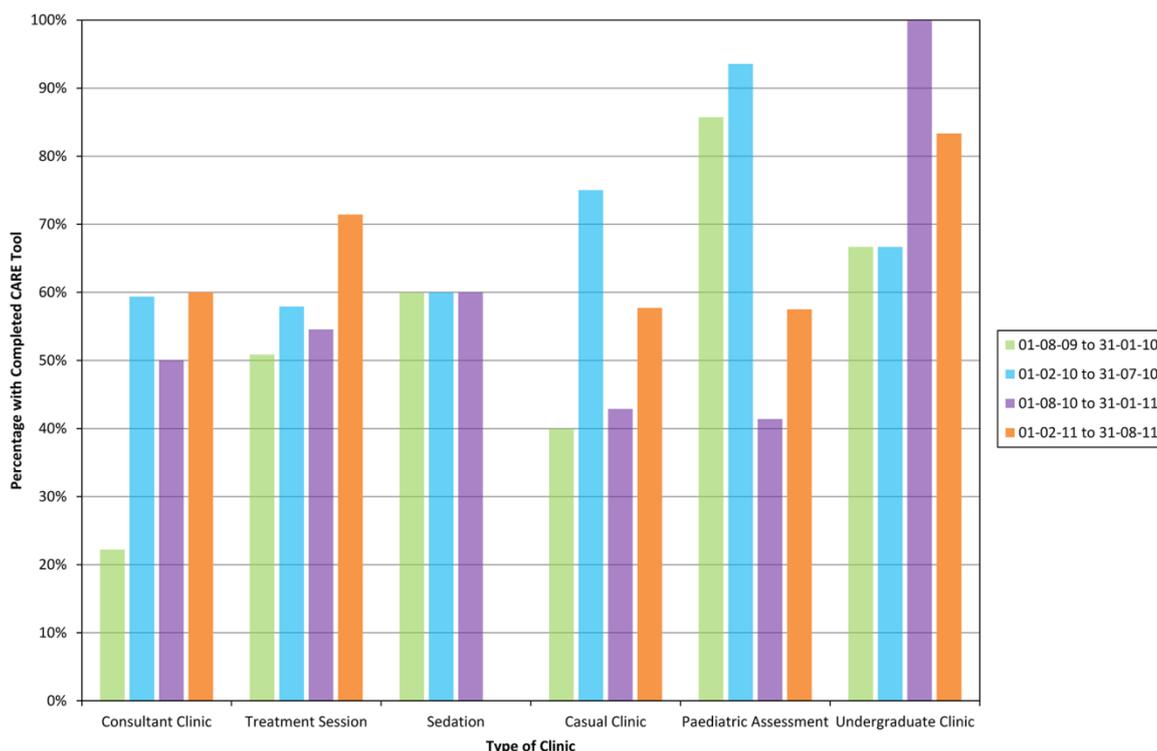


Figure 40 February 2011 to August 2011 Performance by Clinic Type

Table 35 February 2011 to August 2011 Performance by Clinic Type

Type of Clinic	No. of Patients Inc. in Monitoring	% of Total No. of Patients	No. of Patients with Completed CARE Tool	% of Patients with Completed CARE Tool
Consultant Clinic	35	23%	21	60%
Treatment Session	42	28%	30	71%
Sedation	1	1%	0	0%
Casual Clinic	26	17%	15	58%
Paediatric Assessment	40	27%	23	58%
Undergraduate Clinic	6	4%	5	83%

In this period there were improvement seen on both consultant clinics and treatment sessions, suggesting that actively encouraging SHOs to get a consultant to sign off a CARE sheet treatment plan had a positive influence on results. Casual clinic and paediatric assessment show improvement as PCPCS supplies returned during this period. However, results are lower than compared to the February 10' to July '10 period, when the PCPCS was available for the whole period.

Again the undergraduate clinic only had 83% completion, whilst 100% of the patients seen by an undergraduate had a completed CARE tool. As in the February '10 to July '10 period, this was due to a patient who was booked into the undergraduate clinic not being suitable for the undergraduate to treat. This meant that an unexpected change had to be implemented on the day, with the result being that patient did not receive optimal care.

The result for sedation clinics in this period was 0%; however, this was from a sample of 1 patient, so little can be inferred from this result.

7.4.4 Barriers Identified

1. Analysis of previous 6 months results by staff group identified a training need amongst the SpRs and Specialists.
2. Continued lack of PCPCS availability.
3. SHO's not getting CARE sheet treatment plans signed off by consultants on new patient clinics.

7.4.5 Change Concepts

1. Brief education meeting held with SpRs and Specialists to go over the CARE project, and how to appropriately use the various CARE tools.
2. Every effort made to secure supplies of PCPCS. With new supplies arriving at the end of April.

3. A “wash up” huddle introduced at the end of new patient clinics. This allowed junior trainees to discuss cases they had seen with the consultant and ensure all the CARE sheet treatment plans were signed off.

7.4.6 End Survey

7.4.6.1 Methods – End Survey

At the end of the project the launch survey was slightly modified, with some questions removed as no longer being relevant, whilst others were changed or added to address issues pertinent by the end of the project (See Table 36). As no specific meeting or event coincided with the end of the project questionnaire were email and directly given out to all clinicians and nursing staff within the department (n = 18). Administration staff were not included as they no longer had any significant contact with the CARE project by the end of the 25 months. The aim of which was to assess if opinions had markedly changed since the CARE launch and allow an opportunity to identify any new barriers.

Table 36 End Survey Questions

Behaviour Domain	Question(s)
Knowledge	<ol style="list-style-type: none"> 1. “I understand how the CARE project has progressed so far?” 2. “My induction to the department included adequate information on the CARE project?”
Beliefs about Consequences	<ol style="list-style-type: none"> 3. “The CARE project has been a benefit to patients?” 4. “The CARE tools are of use in managing patients?” 5. “The Primary Care Provider Sheet is of use in managing patients?” 6. “The updated Trauma Stamp is of use in managing patients?” 7. “The new CARE Sheet is of use in managing patients?” 8. “Taking patient's heights and weights is of benefit?”
Motivation and Goals	<ol style="list-style-type: none"> 9. “I understand the aims of the CARE project?” 10. “The CARE project has changed working in the department for the better?”
Environmental Constraints	<ol style="list-style-type: none"> 11. “The CARE project has generated extra work for myself?”

7.4.6.2 Results – End Survey

From these questionnaires only 10 completed responses were received (55.6% response rate) (See Figure 41, Table 37 and Table 38).

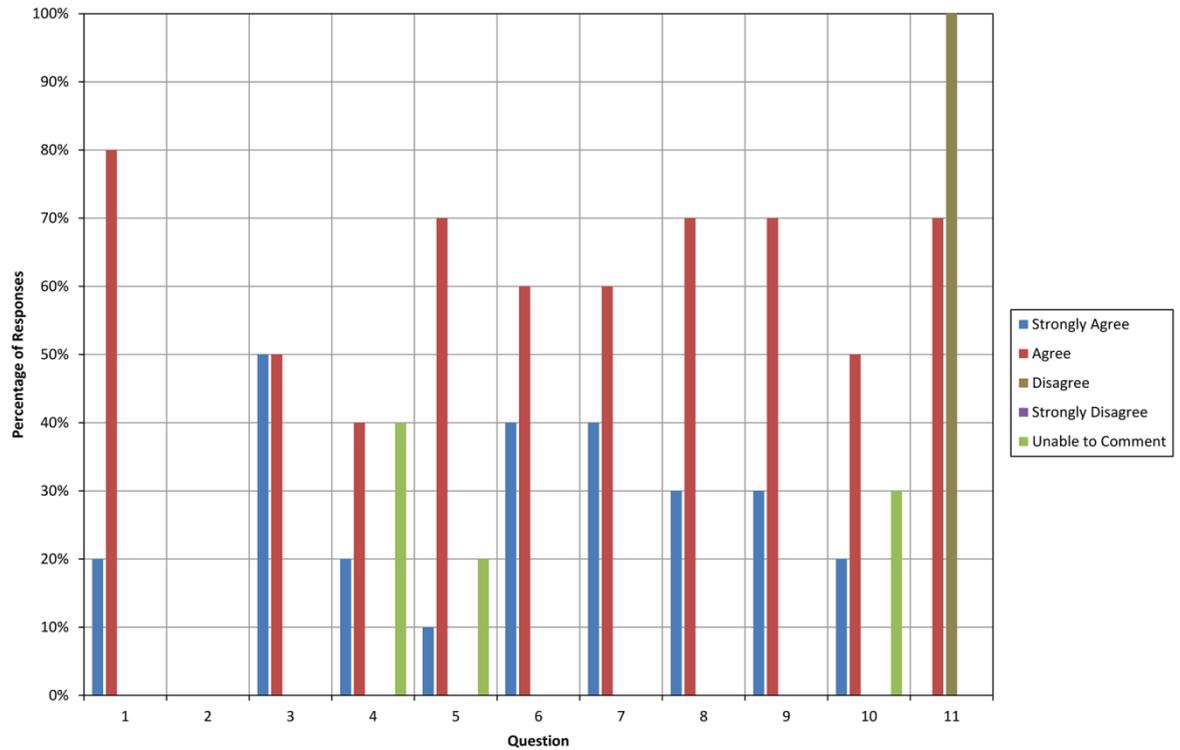


Figure 41 Responses to End Survey Questionnaire

Table 37 Results from End Survey Questionnaire

Question	Behaviour Domain	Responses (Percentage of Responses)				
		Strongly Agree	Agree	Disagree	Strongly Disagree	Unable to Comment
1 I understand how the CARE project has progress so far?	Knowledge	2 (20%)	8 (80%)	0 (0%)	0 (0%)	0 (0%)
2 My induction to the department included adequate information on the CARE project?		0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
3 The CARE Project has been a benefit to patients?	Beliefs about Consequences	5 (50%)	5 (50%)	0 (0%)	0 (0%)	0 (0%)
4 The CARE tools are of use in managing patients?		2 (20%)	4 (40%)	0 (0%)	0 (0%)	4 (40%)
5 The Primary Care Provider Sheet is of use in managing patients?		1 (10%)	7 (70%)	0 (0%)	0 (0%)	2 (20%)
6 The updated Trauma Stamp is of use in managing patients?		4 (40%)	6 (60%)	0 (0%)	0 (0%)	0 (0%)
7 The new CARE Sheet will be of use in managing patients?		4 (40%)	6 (60%)	0 (0%)	0 (0%)	0 (0%)
8 Taking patient's heights and weights is of benefit?	Motivation and Goals	3 (30%)	7 (70%)	0 (0%)	0 (0%)	0 (0%)
9 I understand the aims of the CARE project?		3 (30%)	7 (70%)	0 (0%)	0 (0%)	0 (0%)
10 The CARE project has changed working in the department for the better?		2 (20%)	5 (50%)	0 (0%)	0 (0%)	3 (30%)
11 The CARE project has generated extra work for myself?	Environmental Constraints	0 (0%)	7 (70%)	3 (30%)	0 (0%)	0 (0%)

Table 38 Respondent Comments to End Survey Questionnaire

Question	Comment(s)
1	<i>(no comments)</i>
2	<i>(no comments)</i>
3	Better preventive care given and resources.
4	<i>(no comments)</i>
5	Not sure if it is of use for the primary care providers or if they are so used to seeing it that they ignore it. This sheet ensures not only caries risk assessment but also letters now go back to primary care provider – despite no secretarial support and departmental secretary gone.
6	Yes so that caries risk is documented, but no if not put in letter to GDP etc.
7	<i>(no comments)</i>
8	But on clinic we don't necessarily see how it is of benefit. Different if you are repeating measurements. The BMI project and pathways for obese and underweight children – ideal!
9	<i>(no comments)</i>
10	Caries risk assessment now part of routine clinical practice.
11	Not “excessive extra work” but just a little more. Extra paperwork however now part of clinical care.
General	The run charts were essential to the departmental motivation as well as the individual motivation for each clinician. Feel CARE project has improved patient care and continuity. Although this project clearly been a lot of work, the patients are benefiting in a number of ways.

7.4.6.3 Discussion – End Survey

The response rate for the end survey was marked lower than the launch survey (100% v 55.6%). This demonstrates the effect of the different approaches to distributing the two questionnaires. For the launch survey, they were distributed at a specific event for immediate completion. In contrast, for end survey, the questionnaire was firstly emailed to clinicians and nurses to print out, complete and return. This was followed up with personally finding individuals and handing them a hard copy of the questionnaire to complete. Given the different sites and working patterns of all the individuals involved this was difficult and time consuming. They were encouraged to complete and return them immediately; however, allowances were made for staff to return anonymously at a later point, to encourage them to be robust and honest.

Of those who did complete a questionnaire, the proportion of positive responses at the end of the CARE project had markedly increased when compared to the launch survey. This gave a suggestion that the QI efforts of the inventing 25 months had been successful in influencing the opinions of the staff within the department. None of the responses received indicated any areas of active concern, though a much reduced, though significant, proportion did not give an active opinion in a few areas. These may represent individuals who do not feel they are involved in some elements of the CARE project, or may represent the “laggard” group in relation to the diffusion of innovations (See 1.3.10.1 Diffusion of Innovations, Page 58). Either way, this still indicates that work remains in ensuring comprehensive engagement with staff.

7.4.7 2007 v 2010 Survey

The secondary aim of the project was to assess the subsequent impact the project had on improving rates of documented delivery of caries prevention interventions. This was done by carrying out a number retrospective surveys on samples of patient case notes. Prior to the CARE project this had been done in 2007 as a departmental audit, which provided the initial impetus for undertaking the CARE project. During the pilot and CARE project, comparisons were made between patients with a completed CARE tool and those without. These surveys indicated that the presence of a completed CARE tool was resulting in an improvement in subsequent documentation of caries prevention. Therefore, there was a suggestion that preventive care documentation was improved over the course of the CARE project. To evaluate this, a survey of case notes prior to any QI interventions in 2007 with those after establishment of the QI programme in 2010 was undertaken.

7.4.7.1 Methods – 2007 v 2010 Survey

Based on the data from the previous surveys a power calculation was performed (See Appendix 9). A clinical significance of 30% was selected and to achieve 90% power a sample size of 63 would be required in each group.

The two year groups selected were 2007, prior to any QI interventions in this area within the department, and 2010, when the CARE project was fully

established. For each of these years the unique hospital identification numbers of every patient who attended the department of paediatric dentistry were extracted from the hospital computerised appointment system and entered into a secure database (Microsoft Access 2008, Redmond, Seattle, USA). A random number generator (www.random.org) was used to select 100 patients from each of the two year groups. A sample size of 100 was selected as the experience with requesting notes for the monitoring of caries risk completion, suggested that a significant proportion of case notes were likely to be unobtainable.

The notes for these patients were reviewed for preventive interventions delivered before 31/12/07 for the 2007 group or 31/12/10 for the 2010 group. The same criteria was used regarding delivery of preventive interventions, as the “With and Without CARE Tool Surveys” (See 3.3.1 Methods - 2008-09 With and Without CARE Tool Survey, Page 95), with the addition of the following:

- **Caries risk assessment (CRA)** - was there any form of documentation stating the caries risk status of the patient.

Data were entered directly into a spread sheet (Microsoft Excel 2008, Redmond, Seattle, USA), and for both year groups percentages for all of the above preventive elements calculated. Any of the preventive elements which showed a percentage difference of 30% or greater was to be considered significant.

7.4.7.2 Results – 2007 v 2010 Survey

From the 100 case notes request for both 2007 and 2010, 80 and 79 cases notes were available for analysis, meeting our 63 case notes requirement for power. Demographic information, collected from the hospital computerised appointment system, between those case notes available for analysis and those which were not available was collected (See Table 39).

Table 39 Demographics of Patient's Selected for 2007 v 2010 Analysis

	2007		2010	
	Case Notes Available	Case Notes Not Available	Case Notes Available	Case Notes Not Available
Number	92	8	94	6
Mean Age (Years)	8.46 (s.d. 3.50)	9.25 (s.d. 3.37)	8.06 (s.d. 3.91)	6.67 (s.d. 3.01)
Male	41 (44.57%)	4 (50.00%)	40 (43.01%)	2 (33.33%)
Female	51 (55.43%)	4 (50.00%)	53 (56.99%)	4 (66.67%)
Mean SIMD Quintile	2.22 (s.d. 1.41)	1.63 (s.d. 1.19)	2.38 (s.d. 1.45)	2.83 (s.d. 2.04)
Mean Number of Visits	1.66 (s.d. 1.24)	2.38 (s.d. 2.20)	1.46 (s.d. 0.91)	1.50 (s.d. 0.84)

From the analysis of the available case notes for preventive interventions, the following results were found. The percentage difference between 2007 and 2010 for each preventive intervention was calculated (StataIC V 10.1, Stata Corp, Texas, USA), with a 95% confidence interval (CI) and p-value based on a z-test (See Figure 42 and Table 40).

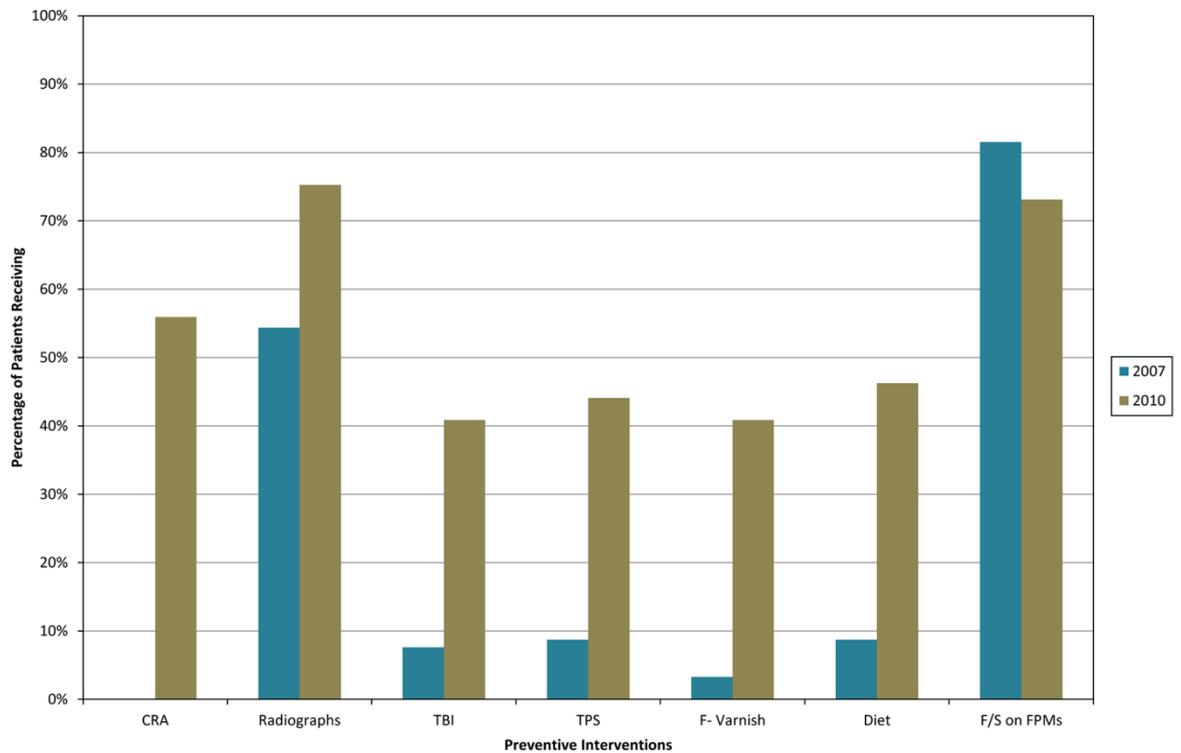
**Figure 42 Percentage of Patients Receiving Preventive Interventions 2007 and 2010**

Table 40 Percentage of Patients Receiving Preventive Interventions in 2007 and 2010

Preventive Intervention	Percentage of Patients Receiving		Difference	95% CI	p-value
	2007 n = 92	2010 n = 94			
CRA	0 (0.0%)	52 (55.3%)	55.3%	45-65%	<0.001
Radiographs	50 (54.3%)	70 (74.5%)	20.1%	6-34%	0.004
TBI	7 (7.6%)	38 (40.4%)	32.8%	22-44%	<0.001
TPS	3 (3.3%)	38 (40.4%)	37.2%	27-48%	<0.001
F ⁻ Varnish	8 (8.7%)	41 (43.6%)	34.9%	23-46%	<0.001
Diet	8 (8.7%)	43 (45.7%)	37.0%	25-49%	<0.001
F/S on FPMs	76 (82.6%)	68 (72.3%)	-10.3%	-22-16%	0.094

7.4.7.3 Discussion – 2007 v 2010 Survey

In both groups the majority of the case notes requested where available for analysis (2007 = 92%, 2010 = 94%), which allowed us to achieve our target sample size. This high level of availability was not initially expected, based on the experience of difficulties in requesting notes for the regular caries risk monitoring. The difference between this survey and the regular caries risk monitoring, was that results could be collected over many weeks, without detriment to the project. Clinical significance was set at 30% for this survey given the experience from the previous 2007 departmental survey (See 2.2 2007 Departmental Survey, Page 90), which found extremely low levels of compliance across the majority of the preventive interventions. Therefore, a threshold of 30% was felt to be acceptable for this survey.

The results from this survey are not comparable with those from the 2007 departmental survey (See 2.2.2 Results - 2007 Departmental Survey, Page 90). This is due to different criteria being applied in this survey, i.e. fluoride varnish needing to be applied at least one within the last six months, or radiographs of diagnostic benefit of posterior caries needing to be taken in line with the patients caries risk status. Also the sample used in the 2007 departmental survey was 25 consecutive patients on the postgraduate treatment sessions, whilst in this survey a random sample from all patients who attended the department that year was used.

Clinically significant improvements between 2007, prior to the CARE project, and 2010, when the CARE project was well established, were found for; CRA, radiographs, TBI, TPS, F⁻ Varnish and diet advice. A 10% fall in fissure sealants

was found between 2007 and 2010, however, this was not found to be significant. Given the 2007 performance in the fissure sealant category, achieving significant improvement would have been challenging. Therefore, effectively maintaining performance around the same high level was considered acceptable. Overall 6 out of the 7 preventive interventions assessed showed significant improvement following establishment of the CARE project. Whilst the 2010 results show that a need for further improvement remains, this is a significant step forward in comparison to the 2007 results.

7.4.8 Dissemination of Results

During this time period there were further opportunities to present the CARE project. Firstly in March to the local West of Scotland BSPD branch we were able to discuss our experience with the loss of PCPCS supplies. Secondly in April we were invited to present the results of the pilot project at the International Forum on Quality and Safety in Healthcare. Our project was the only project at the Forum related to oral health.

A summary of how information was disseminated over this period is given in Table 41.

Table 41 Dissemination Methods February 2011 to August 2011

Date	Event (Method of Presentation)	Presenter	Topics Covered
March '11	West of Scotland BSPD (Oral)	AK	Progress of CARE project Impact of lack of PCPCS
March '11	Clinical Governance (Oral)	AK SHO	Progress of CARE project Barriers identified Changes introduced
April '11	International Forum on Quality and Safety in Healthcare (Poster)	AK	Results of the pilot project
Every 6 weeks	Departmental email (Email)	AK	Progress of CARE project
Every 6 weeks	Departmental QI notice board		Progress of CARE project

7.4.9 Knowledge Gained

Again education was shown to be an important influence on performance, with big jumps seen in the SpR and Specialist group. For the SpRs it was due to members of staff returning to work, following a period of leave. In contrast the staff members in the Specialist group had not significantly changed at any point; however, they appear to have significantly benefited from this educational intervention. This suggests the importance of continually reinforcing education and training, to ensure that staff members are fully aware of the behaviours expected of them.

It took 21 weeks for new supplies of the PCPCS to be secured, which had a significant negative impact on the overall performance of the project. Once it became apparent that new supplies were not going to be quickly secured, the working group did discuss developing an alternative. However, there was great reluctance to do this, as the PCPCS was a tool that we knew worked well. If a new alternative was developed, it was unlikely that it could immediately fulfil all the roles of the PCPCS, along with the additional complexity for staff on the clinics that used the PCPCS as they would have to learn to use the new tool. Therefore, it was decided to continue to pursue securing new supplies of the PCPCS. This was eventually achieved by frequently reminding management about the issue with emails and seeking out managers to ask them in person on a weekly basis until supplies arrived.

Getting SHOs to get treatment plans checked and signed off by consultants was seen to be an important clinical governance issue, as it provides documented evidence that staff are working to a consultant treatment plan. This provided the CARE project with a potential feedback loop, as it introduced a further check for completion of a CARE sheet at the end of new patient clinics. Also it was hoped that by the SHOs presenting the consultant with a fully completed CARE sheet for checking, this might act as a prompt in changing the behaviour of the consultant group. However, by the end of this period there remained issues with the implementation of this “wash up” period, as consultant clinics are often busiest at the end and can often be running out of time.

7.5 Complete 25 Months – August 2009 to August 2011

A summary of the barriers identified and change concepts introduced throughout the 25 months of the CARE project are summarised below (See Table 42).

Table 42 Barriers and Change Concepts Complete 25 Months – August 2009 – August 2011

Barrier	Behaviour Domain	Change Concept	Date Implemented
1. SHOs not fully aware of CARE project.	Knowledge	1. Education and engagement of SHOs.	October 2009
2. Delay in collecting uptake results.	Environmental Constraints	2. Meeting with medical records manager.	November 2009
3. Concern about preventive care follow up post exodontia GA.	Environmental Constraints	3. Meeting with Dental Public Health Team to explore Childsmile links.	December 2009
4. Not all student tutors aware of CARE tools.	Knowledge	4. Email sent to all student tutors.	February 2010
5. Ensure SHO involvement from start of rotation.	Knowledge and Social Influences	5. CARE project as part of SHO induction.	February 2010
6. Lack of consistent placement of CARE sheet in new patient notes.	Environmental Constraints and Professional role	6. Nursing staff begin CARE sheet by taking heights and weights of new patients.	March 2010
7. Clinician feedback identifies elements of CARE sheet hampering uptake.	Nature of the behaviour	7. Revision of CARE sheet.	October 2010
8. Supplies of PCPCS run out.	Environmental constraints	8. Liaison with management to secure new supplies.	November 2010
9. Lack of knowledge in SpR and Specialist group	Knowledge	9. Education delivered to SpRs and Specialists	February 2011
10. Continued lack of PCPCS availability.	Environmental Constraints	10. New supplies of PCPCS arrive.	April 2011
11. SHOs not getting CARE sheets signed off by consultants.	Social Influences and Behavioural Regulation	11. Post clinic “wash up” introduced.	May 2011

7.5.1 Run Chart

A run chart for the full 25 months of the CARE project, with change concepts from Table 42 annotated, is given below (See Figure 43).

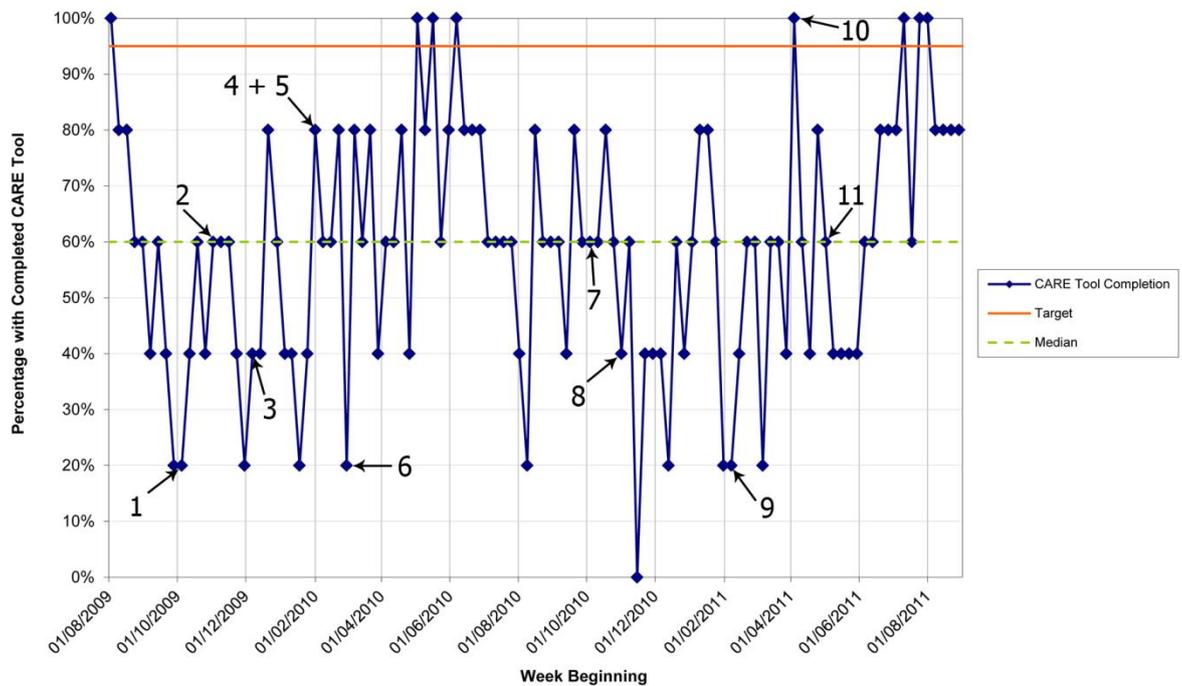


Figure 43 Complete 25 Month Run Chart
Annotated numbers relate to implementation of Change Concepts as list on Table 42.

From Figure 43 the overall median for the full project was 60%, whilst the number of useful observations was counted as being 71. This value was then used to calculate a lower and upper value for the number of expected runs for the CARE project run chart.

$$\text{Lower Limit for Expected Runs} = \frac{71}{3} = 23.67 \text{ (Rounded Down} = 23)$$

$$\text{Upper Limit for Expected Runs} = \frac{2 \times 71}{3} = 47.33 \text{ (Rounded Up} = 48)$$

The number of runs on the CARE project run chart was then found, as shown in Figure 44.

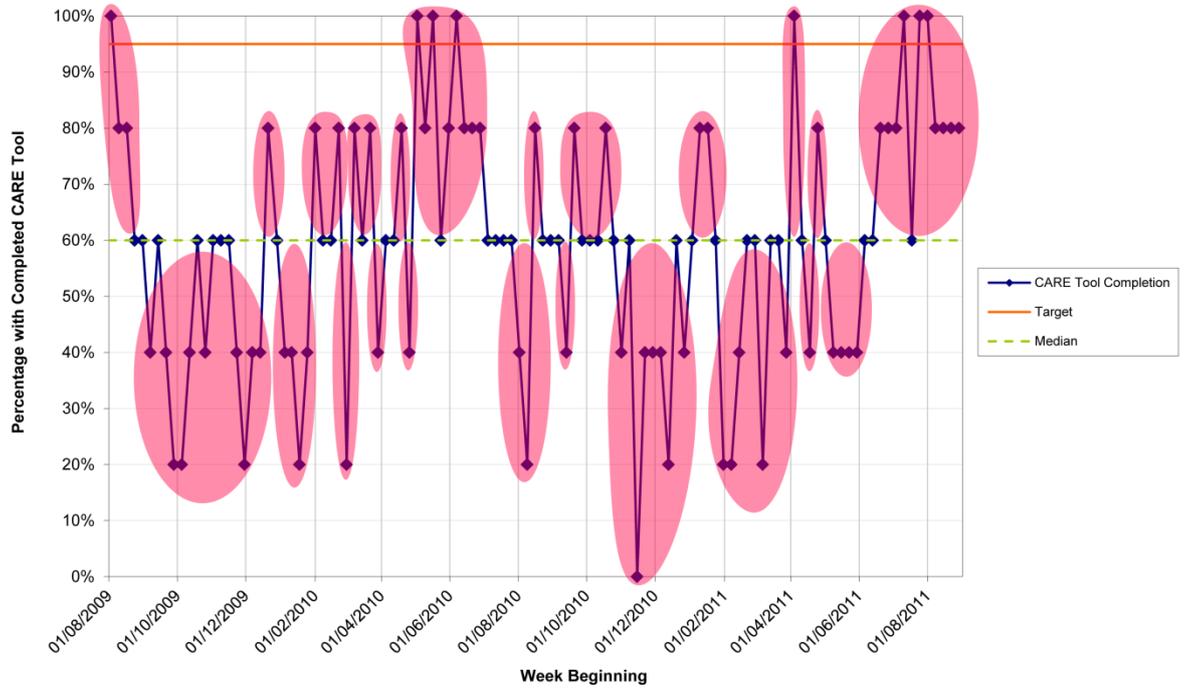


Figure 44 Complete 25 Month Run Chart (Number of Runs)

Figure 44 shows that there are 23 runs on the CARE project run chart. As this falls within our calculated limits no special cause variation is detected using this rule.

As the run chart has now been combined to show the full 25 months, the shift rule can be applied to detect if any periods of special cause variation applied during the project that has not be detected in previous analysis (See Figure 45).

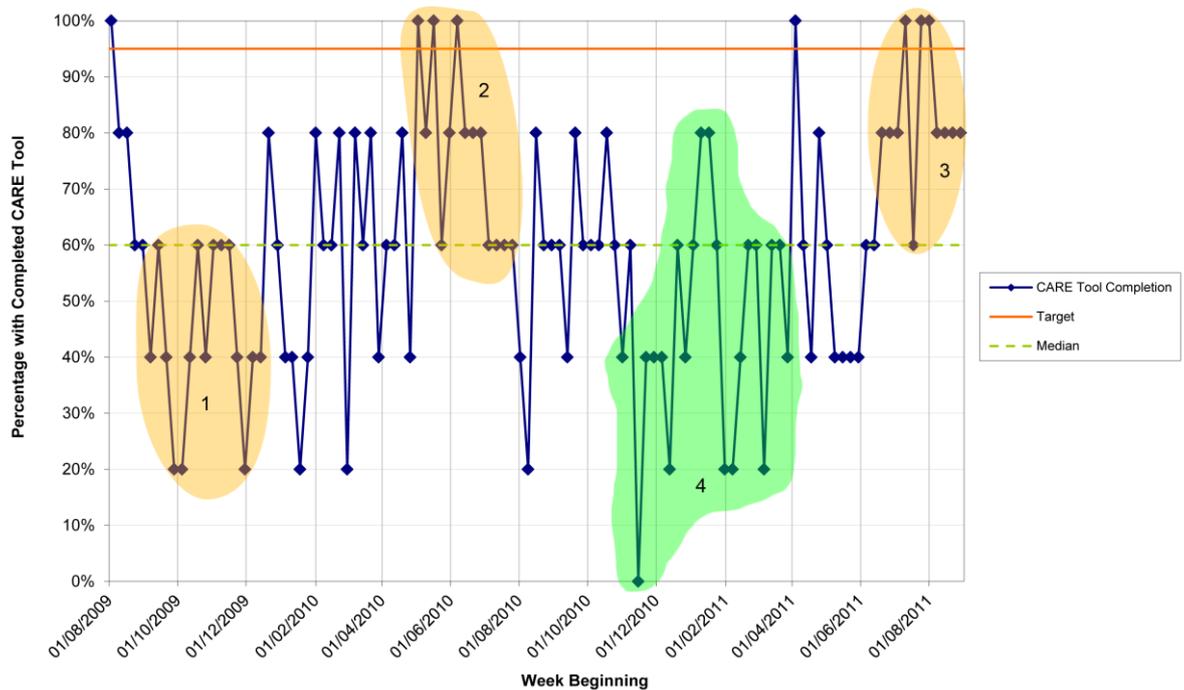


Figure 45 Complete 25 Month Run Chart (Shifts)

Area 3 was detected in previous analysis as shifts and have already been discussed (See 7.4.1 Run Chart, Page 151). As the median for the full 25 months is 60%, compared to 40% in the August '09 to January '10 run chart (See Figure 20, Page 119) the area 1 now qualifies as a shift. Area 2 now also qualifies as a shift due to a change in median, this time from 70% in the February '10 to July '10 run chart (See Figure 26, Page 134). Area 4, whilst not fully conforming to the strict definition of a shift as previously discussed (See 7.3.1 Run Chart, Page 142), represents a period of time where there was a marked negative shift in performance. This period maps exactly to the period where the PCPCS was unavailable, which runs from point 8 to 10 on Figure 43.

Of the other run chart rules, only cyclical pattern appears to indicate any other special cause variation (See Figure 46). It appears that performance deteriorated in the two August to January periods (areas 1 and 3). In contrast, performance appears to improve in the February to August periods (areas 2 and 4). From the limited number of cycles observed during the 25 months of the project it is difficult to fully assess whether there truly is a seasonal effect here, especially as the performance in area 3 was significantly impacted by the loss of PCPCS supplies. It does appear that performance at the start of areas 1 to 4 shows an initial decline in performance. As this corresponds to the introduction of new SHOs into the department, this further reinforces the importance of a more focused SHO induction.

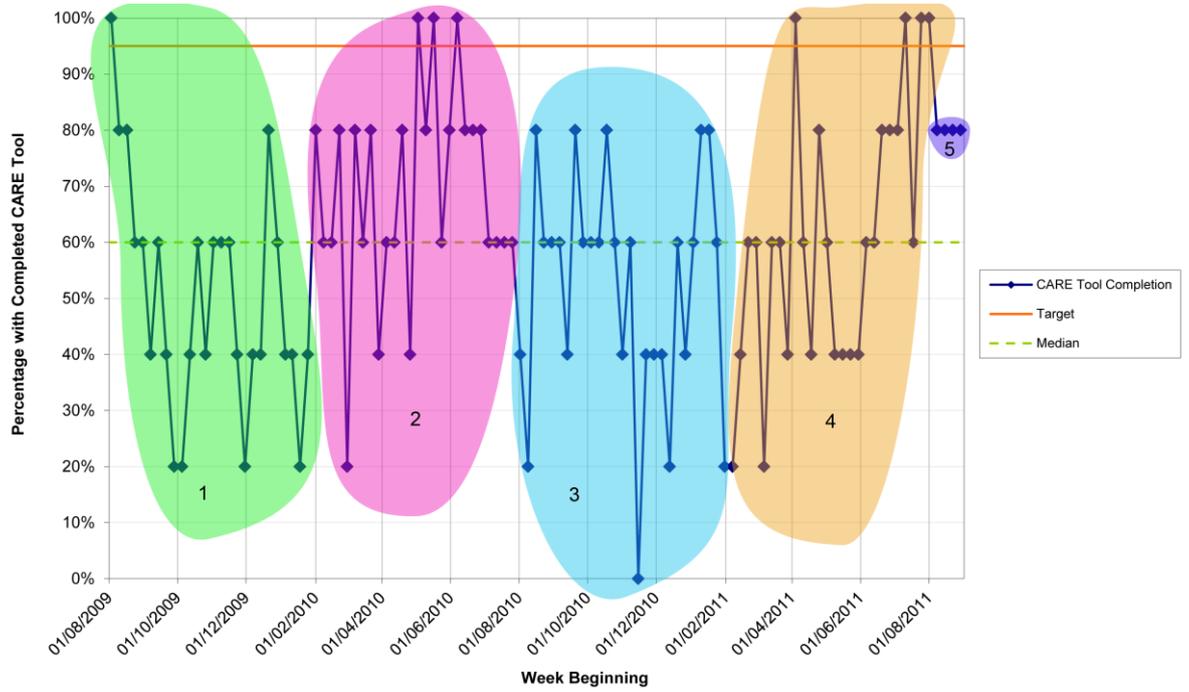


Figure 46 Complete 25 Month Run Chart (Cyclical)

7.5.2 CARE Tool Completion by Staff Type

The mean level of performance of the different grades of staff can be calculated for the full 25 months, with this result compared to the level of performance in each of the previous 4 time periods (See Figure 47 and Table 43).

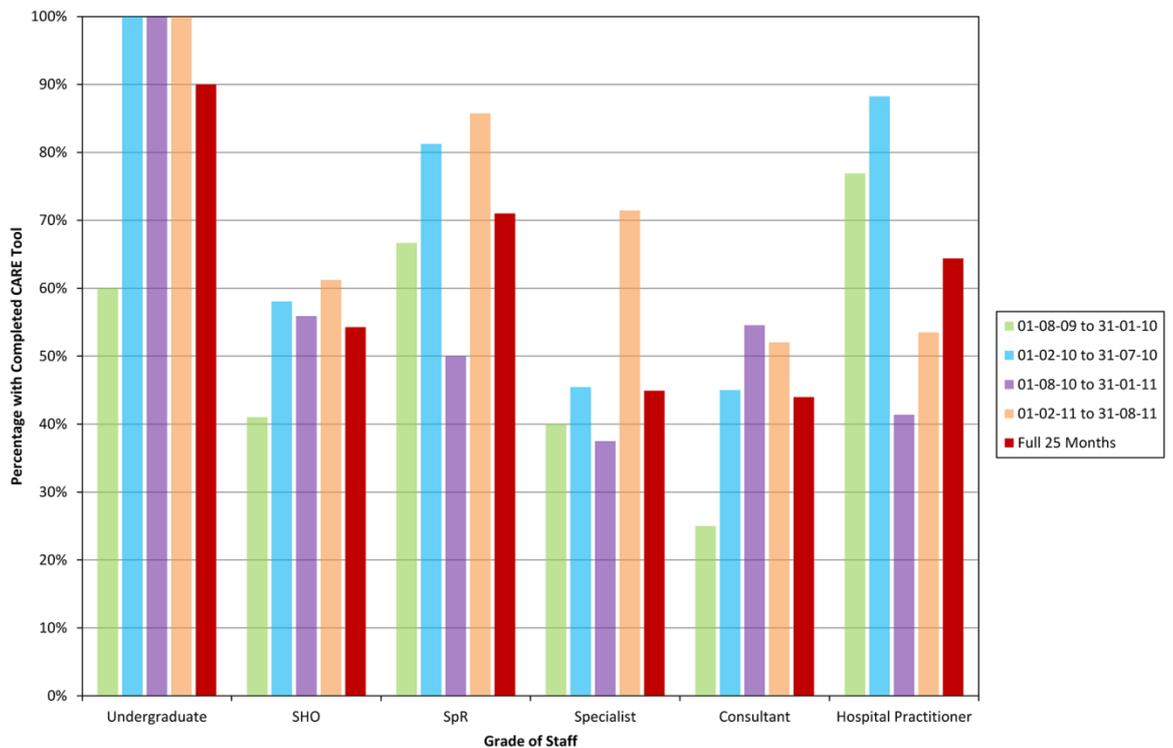


Figure 47 Complete 25 Month Performance by Grade of Staff

Table 43 Complete 25 Month Performance by Grade of Staff

Grade of Staff	No. of Patients Inc. in Monitoring	% of Total No. of Patients	No. of Patients with Completed CARE Tool	% of Patients with Completed CARE Tool
Undergraduate	20	4%	18	90%
SHO	153	28%	83	54%
SpR	100	18%	71	71%
Specialist	49	9%	22	45%
Consultant	91	17%	40	44%
Hospital Practitioner	132	24%	85	64%

To assess whether an association was present between the grade of staff and completion of a CARE tool, Fisher's exact test was used (StataC V 10.1, Stata Corp, Texas, USA). This strongly showed that the grade of staff completing the case note did impact on whether a CARE Tool was completed ($p < 0.001$). This provides further evidence that quality of care within the department was variable; with different groups of staff showing different levels of compliance with the CARE project.

When reviewing the performance with the groups over the 25 months the undergraduates performed consistently high; other than in the initial August '09 to January '10 period. For the SHOs, performance was also poorest in the initial period. However, despite the fact that this group of staff changed in each period, their results were surprisingly stable for the majority of the project. It had been thought that it was the intrinsic motivation amongst the different groups of SHOs that primarily determined their performance. However, these results appear to suggest that other unknown barriers are inhibiting their performance.

A decrease in performance for the SpRs is seen in the August '10 to January '11 period, but overall they tended to be one of the better performing groups. The Specialists showed an improvement in performance during the final February '11 to August '11 period; whilst the performance of the Consultants remains relatively static at around 50%. Finally, the hospital practitioners are the group whose results are significantly influenced by the availability of the PCPCS - from August '09 till July '10, when there were no issues relating to PCPCS availability, their completion of a CARE tool is over 75%. In contrast, in the periods when

there was a lack of PCPCS availability, there is a corresponding fall in performance.

7.5.3 CARE Tool Completion by Clinic Type

The mean level of performance of the different types of clinic was calculated for the full 25 months, with this result compared to the level of performance in each of the previous 4 time periods (See Figure 48 and Table 44).

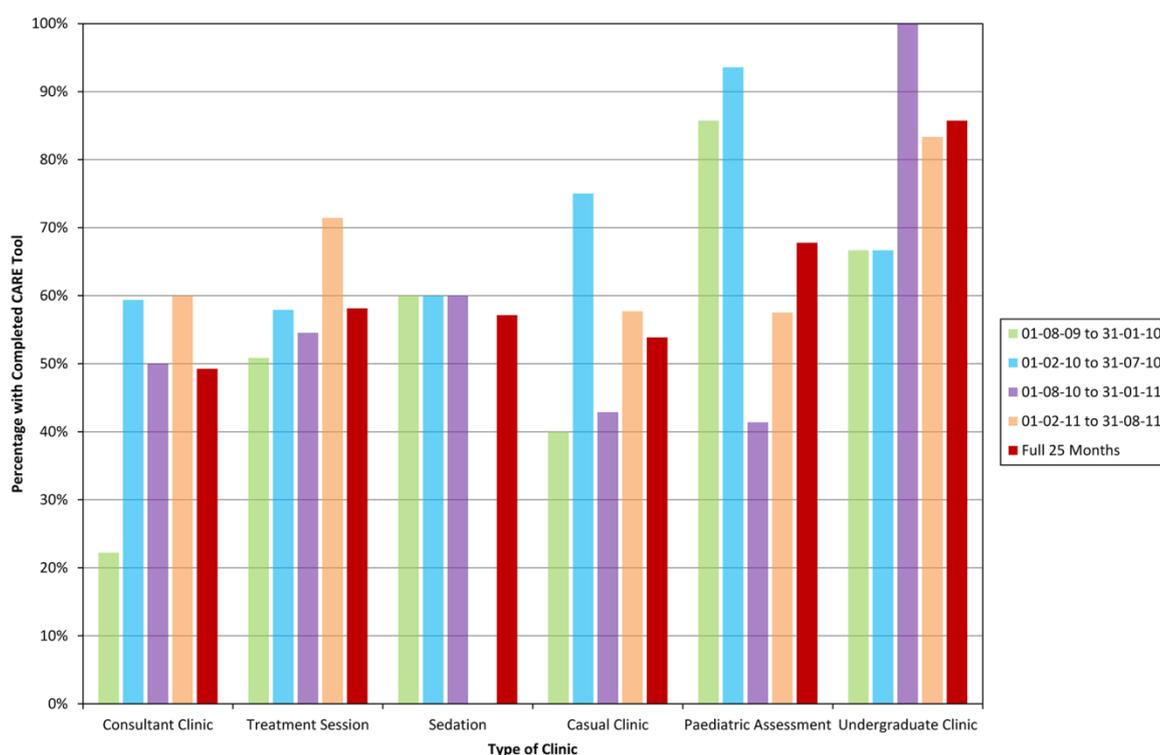


Figure 48 Complete 25 Month Performance by Clinic Type

Table 44 Complete 25 Month Performance by Clinic Type

Type of Clinic	No. of Patients Inc. in Monitoring	% of Total No. of Patients	No. of Patients with Completed CARE Tool	% of Patients with Completed CARE Tool
Consultant Clinic	132	24%	65	49%
Treatment Session	172	32%	100	58%
Sedation	21	4%	12	57%
Casual Clinic	78	14%	42	54%
Paediatric Assessment	121	22%	82	68%
Undergraduate Clinic	21	4%	18	86%

To assess whether the type of clinic a patient attended influenced whether a CARE tool was completed Fisher's exact test was used (StataIC V 10.1, Stata Corp, Texas, USA). This found that there was a significant association between the type of clinic attended and completion of a CARE tool ($p = 0.04$).

For both the sedation and undergraduate clinics, previous discussion has highlighted that sample size in each of the individual time periods was small, and so large swings in results have occurred because of only a few patients. However, the mean results for the 25 months show that the undergraduate clinics had the highest level of performance, whilst the overall performance on the sedation clinics was similar to that on treatment sessions; which was to be expected. The performance on treatment sessions was relatively consistent, though the final 7 months appears to show some positive improvement.

Consultant clinics were one of the areas where a significant number of interventions were directed. There was a large jump in performance following the first 6 months; however, the performance remained relatively static, despite the number of intervention directed at these clinics. Casual clinics showed a significant level of variation in performance between the 4 different time periods, though the 25 months mean of 54% is similar to other treatment and sedation clinics. There will have been some impact of the loss of PCPCS supplies in the August '10 to January '11 period, as the PCPCS was intended to be used on the casual clinic and this was reflected in the results. As the casual clinics are primarily staffed by the SHOs, a large part of the variability is likely due to differences in SHO training and motivation in each of the 4 time periods.

The impact of the lack of PCPCS supplies can strongly be seen on the results of the paediatric assessment clinics. When the PCPCS was fully available over 80% of patients attending these clinics were having a CARE tool completed; when supplies ran out this fell to 41% and had only recovered to 58% in the final 7 months. Overall 22% of all the case notes sampled during the CARE project came from the paediatric assessment clinics, therefore, performance on these clinics contributed considerably to the overall performance recorded by the department.

7.5.4 Dissemination of Results

Results from the project were disseminated frequently, as this was felt to be a useful way of reinforcing knowledge about the project, along with encouraging the shift to an open culture of improvement we were attempting to foster. The table below give a full list of the dissemination efforts undertaken (See Table 45).

Table 45 Dissemination of Results

Date	Event (Method of Presentation)	Presenter	Topics Covered
August '09	CARE Launch (Oral)	AK	Summary of Pilot Project Use of CARE Toolkit New data sampling methodology Aims of CARE project
September '09	BSPD (Oral)	AK	Summary of Pilot Project
October '09	CDS Study Day (Oral)	AK CC SHO	Summary of Pilot Project Use of CARE Toolkit Aims of CARE project
March '10	Clinical governance (Oral)	AK	Progress of CARE project Barriers identified and changes implemented
June '10	EAPD (Oral)	AK	Progress of CARE project QI Methodology Barriers identified
June '10	EAPD (Poster)	CC	Impact of CARE project on preventive care

January '11	CDS Meeting (Meeting)	AK CC	Initiation of a project to evaluate caries risk and prevention completion on undergraduate clinics within GDHS and CDS. Evaluation of compliance in relation to fluoride varnish target.
March '11	West of Scotland BSPD (Oral)	AK	Progress of CARE project. Impact of lack of PCPCS.
March '11	Clinical Governance (Oral)	AK SHO	Progress of CARE project. Barriers identified. Changes introduced.
April '11	International Forum on Quality and Safety in Healthcare (Poster)	AK	Results of the pilot project.
Every 6 weeks	Departmental email (Email)	AK	Progress of CARE project.
Every 6 weeks	Departmental QI notice board		Progress of CARE project

7.5.5 Knowledge Gained

From the full 25 month analysis two additional periods of shift were detected. These were both from the first 12 months of the project, when the median value is more likely to change due to the limited number of data points. These additional shifts corresponded to times during the project already suspected of being under the influence of special cause variation. Figure 45 area 1 (Page 171) corresponds with a time during the CARE project where an identified issue relating to SHO training existed. Whilst Figure 45 area 2 reflects a period when the changes implemented had managed to successfully improve performance to a new level. Unfortunately, following area 2 the run chart shows that performance fell. This indicated that the CARE project had yet to achieve

consistency, and reminded us that improvement is a dynamic process that requires constant vigilance.

The cyclical pattern detected (See Figure 46, Page 173) conformed to the anecdotal suspicions that performance changed significantly in relation to different SHO rotations. However, the staff group analysis (See Figure 47, Page 173) does not fully support this, as it only shows a significant change in SHO performance for the August '09 to January '10 period. In contrast the decreased performance at the start of the rotations detected by the cyclical pattern analysis, does appear to be supported by the evidence relating to the need for adequate training found elsewhere in the analysis (i.e. improved performance of SpR and Specialist in February '11 to August '11 following educational intervention).

When looking at the 25 month means for either staff groups or clinic types, it appears that for the majority the performance level was around 50-60%; leaving significant room for further improvement. Amongst the staff it was the SHOs, specialists and consultants, who were primarily working at this 50-60% level. The SHOs are a group of clinicians, who are generally relatively newly qualified and often require significant support in making clinical decisions. They therefore look to experienced clinicians to guide their behaviours. In contrast the Specialists and Consultants are the most experienced clinicians in the department, generally meaning that they will have developed behaviours based on past experiences. The groups that achieved levels of performance above 50-60% were the undergraduates, who will do what their tutor tells them, the hospital practitioners, who have a reliable system using the PCPCS, and the SpR, who are a group eager to developed their skills and knowledge.

Chapter 8 – Discussion

8.1 Background

8.1.1 Writing for Quality Improvement Projects

Accurate reporting of results from any scientific investigation is critical for the dissemination of knowledge; this is equally true for the reporting of quality improvement projects. Over the centuries the process of writing for scientific publication had been refined. Historically scientific writing was in the form a letter to colleagues or a chronological experimental report. During the course of the twentieth century, scientific writing gradually became standardised around the introduction, methods, results and discussion (IMRaD) structure (Sollaci and Pereira, 2004). The rationale behind this standardisation being that it; eases the reviewing and editing of scientific manuscripts, enhances understanding of papers and ensures important information is not omitted (International Committee of Medical Journal Editors, n.d.). Beyond the IMRad structure, a range of reporting guidelines have been developed, which aim to aid authors, reviewers, editors and readers of the wide range of types of scientific reports now produced (Equator Network, n.d.).

Applying the IMRaD structure to the reporting of QI projects, has proven to be challenging. Primarily as the nature of QI demands an iterative process with methods changing based on knowledge gained from results. Initial reporting guidelines for QI projects proposed by Moss and Thompson did not conform to the IMRaD structure (Moss and Thompson, 1999). These led to debate of whether QI reporting should conform to IMRaD, with specific concerns about a lack of academic rigour if IMRaD was not applied (Davidoff and Batalden, 2005; Thomson, 2005). Eventual consensus was to conform to the IMRaD structure, with the publication of a subsequent set of reporting guidelines – Standard for Quality Improvement Reporting Excellence (SQUIRE) (Davidoff et al., 2008). In the publishing of the SQUIRE guidelines the authors acknowledged that, whilst representing an important step forward, significant complexity in structuring QI reports is yet to be fully resolved. In the construction of this thesis, addressing this complexity proved challenging – requiring significant thought and revision.

8.1.2 Project Protocol

The initial project protocol (See Appendix 4) called for a range of QI methods and targets to be utilised in achieving our aims. This was based on our experience at the end of the pilot project, where we had appeared to have achieved a level of CARE tool completion in the 70%+ range. Our intention was to; stabilise the CRA documentation process around a 95% target using control charts, improve communication of CRA status to the referring practitioner, improve delivery of the appropriate preventive care package, along with a survey of preventive care standards across UK paediatric dentistry units. It quickly became apparent that this approach was overly ambitious, as the results of our CRA completion monitoring rapidly showed that further work was required before we could consider this process stable. Re-evaluation of your approach to QI in response to unanticipated results is a fundamental part of the PDSA model (Langley et al., 2009), as it impossible to fully predict how a system will respond to any changes you introduce.

Liaison with referring practitioners remains an area that offers opportunities for improvement. It is our intention that the work begun with the Childsmile team, relating to the interaction of children with general dental services but prior and post GA extractions, will form the basis of subsequent work in this area.

Although we were unable to extend our application of QI methodologies to fully encompass preventive care delivery, the 2007 v 2010 caries prevention audit did show marked improvement in this area. Finally, whilst a UK survey of preventive care would have provided some interesting discussion points, it would have most likely reinforced the finding that the application of guidelines is inconsistent.

Positively, our effort in actively disseminating this work has subsequently inspired other units in undertaking their own work in this area.

8.1.3 Learning from Other Quality Improvement Projects

The secondment with the SPSP advisor gave an opportunity to see QI projects in practice – a valuable learning experience (See 5.3 Scottish Patient Safety Programme Secondment, Page 100). It was reassuring that other projects experienced similar difficulties in their QI efforts. These experiences provided guidance in the development of our own interventions, based on knowledge

gained from these visits. For instance, during the ICU visit in relation to hand hygiene, discussion recommended that “naming and shaming” was an ineffective method of engaging resistant staff. During the CARE project a similar issue with resistant staff was faced; based on the ICU discussion we were able to discount “naming and shaming” as a potential intervention. Another example of learning from these visits was the discussion on the open display of negative data on the HDU visit. This encouraged the CARE working group to ensure data was continually widely disseminated throughout the project. Finally, significant reassurance was gained from the common difficulty both units were experiencing normalising the culture within their departments around the expected behaviours. This normalisation of the expected behaviour with the social culture is the ideal outcome of any QI project; however, it proves to be illusive.

External support of QI projects through collaborative networks has been identified as a useful tool in helping sustain and develop quality improvement teams (Cunningham et al., 2012). As interaction with external teams, gives opportunities for transfer of knowledge and skills, along with support and motivation. Developing this liaison between QI teams is an important aspect of the overall SPSP strategy to ensure sustained improvement (Haraden and Leitch, 2011), as well as being a key driver for the Institute for Healthcare Improvements Open School initiative. Based on Rogers model of diffusion of innovation, this external social support network is important for those who would act as the innovators in their own environments; as it gives them access to new ideas and likeminded individuals (Rogers, 2003).

At the beginning of the CARE project, there was no other oral health QI project, which we could liaise with in this fashion. Therefore, the open school resources, input from the SPSP secondment, along with discussions with members of the SPSP team at various points during the CARE project, proved an invaluable support. As the CARE project has matured, our intention has been to help support others in developing oral health QI projects.

8.1.4 The Local Setting

The CARE project was based in the hospital dental service, staffed by clinicians who as paediatric dentists should be highly motivated in relation to caries risk assessment and prevention. However, results showed – particularly the 2007 departmental audit – that observed behaviour was not meeting expectation. We were aware that in many cases, the preventive interventions were most likely being delivered to the patient, but not being documented. Given that medicolegally – *if it's not documented, it's not done* – and within the department care is frequently transferred between clinicians, this was a situation that had to change.

This gap between expected and actual practice is at the heart of the QI movement. The majority of dental care in the UK is provided by general dental practitioners, working as independent contractors to the NHS. The clinicians working in this environment have a range of pressures relating to time, cost and regulation; potentially more than are experienced within a hospital department. Our expectation would be that the CARE project could be replicated in the general practice environment. Some of the barriers encountered are likely to be similar to those discussed here. Though, as smaller organisations, often with GDP owner/managers, they would not encounter the same barriers to change that exist in larger organisations, like a dental hospital.

8.1.5 Pilot Project

The pilot project represented our first foray into the use of QI methodologies. A problem relating to the documentation of caries risk assessment had been identified, and the pilot showed that QI methods could be successfully applied in addressing it. Barriers to improvement identified during the pilot included; SHO training, suitability of CARE tools to the clinical situation, along with unexpected difficulties when staff members were ill. Whilst interventions were implemented to address these barriers during the pilot, some continued to be encountered during the CARE project. This highlights the challenge for any QI project in sustaining improvement and ensuring reliability. To achieve reliability Reason *et al.* would have us approach these persistent weaknesses in an open and frank manner, so that they can be acknowledged and collectively managed

(Reason et al., 2001). During the CARE project we embraced this approach, by opening displaying data and frequently discussing progress, both positive and negative, with the intention that this would help foster a culture of improvement.

8.1.6 The CARE Toolkit

Within the dental hospital all clinical records are maintained as a paper based system. This limited the approaches we could take with developing our interventions. Ideally, under an electronic records system, automated reminders could be built in to help ensure the desired behaviours are undertaken, and these have been noted to be effective systems (Delpierre et al., 2004). Given this limitation, we modelled our tools on concepts such as default options, which have been shown to be powerful in influencing clinician's behaviour (Halpern et al., 2007). When default options were placed on the CARE sheet treatment plan, these proved unpopular with some clinicians. This highlights the difficult balance required in QI projects; to influence behaviour to achieve the desired result, without placing overbearing restrictions on individuals. As Deci et al.'s review reported, external factors perceived by the individual to be controlling are likely to degrade the internal motivation to perform the task (Deci et al., 1999).

8.1.7 Staff Surveys

The staff surveys carried out during the project were useful adjuncts to the informal opinion monitoring that occurred as part of the day-to-day running of the project. The main change between the two surveys was the decrease in the size of the proportion who either felt unable to comment or did not answer a number of questions. Part of this will be due to the end survey not including administrative staff, as they were no longer involved by the end of the project and at the beginning may have been the group most uncertain about the project. However, even in the end survey there was a significant proportion of respondents who felt unable to comment. They may represent a group of staff who are either uninformed about the project, or are resistant "laggards" (See 1.3.10.1 Diffusion of Innovations, Page 58). Either way it highlights the continued need to ensure engagement of all staff groups.

Reassuringly those who did give an active response to the questions asked, were overwhelmingly positive; especially so in the end survey. This is a strong indication that commitment to the project improved over the 25 months, which will have helped foster a positive social culture towards the project.

8.2 Quality Improvement

8.2.1 Measurement

The limitation of a paper based records system collection of data proved to be a significant challenge. The limitations of this system used during the pilot project have been discussed previously along with the changes introduced for the CARE project to address these (See Methods - Data Sampling). Whilst these changes did address the issues of bias and infrequent sampling, the new system had three particular limitations of its own.

The first being the delay in collecting results, due to the difficulties in obtaining case notes once they leave the clinic. The reviewing of notes once they had been sent back to medical records filing was an intentional change. It ensured that clinicians who may have completed a CARE tool after leaving the clinic were not penalised and allowed a random sample of all the patients who attended to be selected. Unfortunately, case notes do not immediately return to medical records, but instead can go to clinicians' offices, to secretaries, or other sites like Yorkhill – often for several weeks. Meetings were held with medical records management and changes introduced to help mediate this, but there remained a significant delay in obtaining a full result for each week.

This new sampling method moved the measuring of results off the clinic. Whilst this removed a potential source of bias, by preventing self-selection of positive results, it also reduced the prominence of the project. During the pilot clinicians could openly see the data being collected, highlighting that carries risk documentation was “being looked at” – creating an influence on the culture within the department. For the new system data collection moved away from the clinic and into an individual office, removing this prominence and leading to a sense of detachment between individual clinicians and overall results.

Finally, for the new sampling method the sample size went from 20 per fortnight, to 5 per week. From the outset of developing the new system, it was appreciated that obtaining case notes from medical records in a timely fashion would prove challenging. After discussion with leaders of the SPSP it was decided, based on their experience, that 5 per week would be the smallest acceptable sample size. By using this size it was hoped to reduce the anticipated difficulties with obtaining case notes. Moving to a smaller sample size introduced more variability to results, as a change in one case note would cause a 20% jump in results. The intention was that by moving to a weekly rather than fortnightly data collection scheme, data points would be added to the run chart more frequently allowing analysis rules to be readily applied; negating this increased variability. Whilst use of the run chart rules did give insight into the trends affecting the project, delays were encountered even with the small sample size, which hindered the timely interpretation of results.

8.2.1.1 Data Sampling Systems

The implementation of the revised data sampling system for the CARE project, was intended to address the limitations of the system used for the pilot project (See Table 46). The experience over the course of the both the pilot and CARE projects found strengths and weaknesses with both systems, with neither being ideal.

Table 46 Features of Pilot and CARE Project Data Sampling Systems

Feature	Pilot Project	CARE Project	Comment
Timely Results	Immediate Results	Approx. 6 week delay	As data were collected immediately on the clinic, results were available at the end of the week in the pilot project. Allowing the data to immediately be used to guide project development. In the CARE project, as notes were requested for review once they had returned to medical records, this introduced a sizeable delay into collecting a full week of results.
Visibility of Data Collection	Prominent on Clinic	Hidden	With data being collected prominently on the clinic for the pilot project, this was very visible and helped raise awareness. In the CARE project data collection was away from the clinic and so was not immediately visible to all staff.
Bias	High	Low	The data sampling method in the pilot project was susceptible to bias as notes were selected by the judgement of the investigator on the clinic, from the notes readily available. In contrast selection of notes for the CARE project was in a truly random fashion from any patient who had attended the department in that week.
Clinic Covered by Sampling	Restricted	All	During the pilot project notes were only sampled if there were immediately available to the investigator on the clinic. In the CARE project as notes were randomly selected from any patient who attended the department that week, all clinics were potentially examined for results.
Variability of Results	Low	High	In the pilot project 20 case notes were used to generate the percentage for that week. In contrast only 5 case notes were used during the CARE project, this meant that results were subject to increased variability.

8.2.1.2 Run Charts

The use of run charts in this project, with the tracking of progress against time and annotation of significant events, proved to be a useful method for visually displaying progress. The run chart from the pilot project, with 24 data points, is readily interpreted as showing an overall positive trend of improvement (See Figure 49).

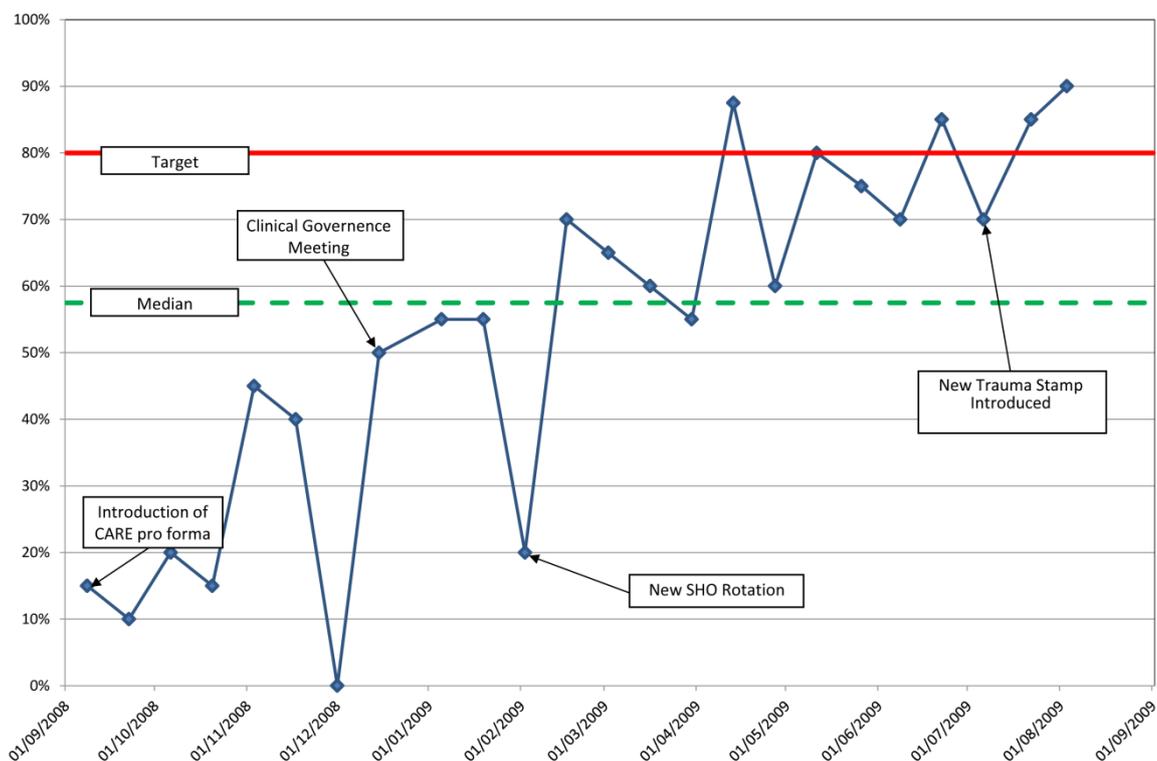


Figure 49 Pilot Project Run Chart

As the CARE project progressed, the number of data points on the run chart increased rapidly, resulting in a run chart with 110 data points (Figure 17 Full CARE Project Run Chart, Page 115). Coupled with the increased variability from the new sampling system, the resulting run chart is complex hampering easy interpretation. Here the application of the run chart rules is obligatory to gain an understanding of the overall trends of the data. When communicating progress to members of the department, care was required to ensure this complexity did not become a barrier to understanding and that the result could be fully comprehended by all.

The analysis of the full 25 month run chart (See Figure 45, Page 171) indicates four different periods where performance was markedly shifted either positively

or negatively, along with some potential cyclical trends (See Figure 46, Page 173). The trend of decreased performance at the start of SHO rotations is a further indication of the importance of appropriate training for this group of junior clinicians. The change of junior clinicians negatively impacting on overall performance, is in line with the reported increase in the hospital mortality rates coinciding with the start of junior doctors in new rotations (Jen et al., 2009). Whilst the appearance of a seasonal trend, showing improvement from February to July, followed by decline in the August to January period, is interesting; comment is limited due to only having four of these periods covered during the project.

A challenge encountered during the construction of this thesis was how to present and discuss the run charts over the full duration of the project. In the literature the trend is to present and discuss the full complete run chart for a quality improvement project, as is done in section 7.5.1. Occasionally, reports due segment the run chart, based on an obvious change or time point. In order to give a clear description of progress across the entire project, it was decided to segment the run charts presented in this thesis based around the 6 month SHO rotations. This segmentation lead to differences when it came to the analysis of the run charts, as certain patterns which are identifiable on the full 25 month run chart (See Figure 43, Page 170) but not the segmented run charts, and vice versa. These differences are purely an artefact of the structure chosen for documenting the project, in reality the run chart was constantly evolving, with patterns being detected as and well they arose.

8.2.1.3 Contrast with Audit

This project looked to explore the use of QI methods to address a clinical issue that would have traditionally been addressed using audit and feedback (See 1.3.1.3 Differences between Research, Audit and Improvement, Page 36). If this project had been undertaken as a more conventional audit exercise, the most significant difference would have been that data would have likely been sampled on a 6 monthly or annual basis. If annual basis had been used, 3 cycles would have been completed between the start of the pilot in 2008 till the end of the CARE project in 2011. On a 6 monthly basis this would double to 6 completed cycles in the same timeframe. In contrast, over the course of the pilot and CARE

project 133 PDSA cycles were completed. This gave far greater scope to test changes and look to identify barriers than the limited number of cycles an annual audit would have provided.

This additional data was not without drawbacks. As discussed previously, the data sampling methods used and interpretation of the run charts provided their own difficulties. The method used to present data has been shown to impact how clinical trials are interrupted (Fahey et al., 1995); this continues to be an important consideration for the presentation of QI data (Allwood et al., 2013). At present the methodologies, data produced and statistical tests used in audit are reasonably familiar to the majority of clinicians; facilitating the dissemination of audit results. Prior to undertaking this work, there was no experience within the department in the use of QI methods or interruption of QI data. This lack of knowledge was further reinforced by our experiences disseminating the results of the project beyond the department. For QI methods to become widely applied within dental health, this knowledge gap will need to be addressed.

8.2.2 Staff Group Performance

The results from the overall analysis of CARE Tool completion by staff type found a significant association between grade of staff the patient saw and whether a CARE Tool was completed ($p < 0.001$, See 7.5.2 CARE Tool Completion by Staff Type, Page 173). Reviewing how performance changed amongst the difference groups of staff over the duration of the CARE project shows how each group were impacted by the various changes and barriers identified during the project.

The hospital practitioners are a group of general dental practitioners who solely work on the paediatric assessment clinic. During the pilot project this was a group whose behaviour was found to be resistant to change. However, the development of the PCPCS, as an intervention aimed primarily at the paediatric assessment clinic and the behaviour of the hospital practitioners, proved to be highly successful. When the supplies of the PCPCS ran out; there was great reluctance to develop an alternative tool because of this success and previous resistance. The introduction of new tool would have likely required the same exercise in overcoming resistance, a potential waste of effort if new supplies of the PCPCS could be secured.

The SHOs are a group who, whilst not formally undertaking training, are in post to gain new skills. They are generally a few years qualified and tend to be looking to gain appropriate experience to facilitate their application for specialist training, though not necessarily in paediatric dentistry. Also the individuals comprising this group changed every 6 months. The experience in the Aug '09 - Jan '10 period was that this group rapidly developed behaviours on arriving in the department, so if the initial opportunity to influence their development is missed, it was significantly more difficult to modify later. However, despite the regular changes in of this group and the subjective levels of engagement with the CARE project between these different groups of SHOs, the results for this group were surprisingly consistent. If the motivation to participate was unique to the individual, their background and training, then greater variation in performance would have been expected. This suggests that an external factor or factors, consistent over the whole project, may have had a greater influence on behaviour than any intrinsic motivation of the differing individuals.

The specialists and consultants are the most qualified group, likely to already have a set of developed behaviours. It is disappointing, though potentially unsurprising, that this group was the most difficult to change behaviour in. Work by Bunce and Birdi found that senior clinicians, who possess greater work autonomy than junior staff, were more likely to develop a routine behaviour approach to clinical tasks (Bunce and Birdi, 1998). This presents an interesting avenue for further potential investigation - this group may have the greatest freedom to determine their own clinical behaviours, yet this freedom possibly inhibits behaviour change; as they may have little impious to escape from established routine behaviours.

Given the social aspect of behaviour change, the perceived intransigence of senior staff to adopt the desired behaviour may have impacted on the behaviours of the more junior staff. An element not investigated during the project was what influence the behaviours of these more senior staff members had on the more junior - particularly the SHO group as the most junior staff group. It is well documented that differences in status between doctors and nurses inhibits the ability of nurses to effectively contribute to the effective care of patients (Coombs and Ersser, 2004). It may therefore be a reasonable

assumption, that the behaviour of senior staff was one of the external factors influencing SHO behaviour. It has been suggested that healthcare organisations which place greater distinction on internal hierarchy are more likely to suffer adverse events, due to junior team members being inhibited in challenging the decisions of their seniors (West, 2000).

However other “junior groups” - undergraduates and SpRs, appear to have been more resistance to the influence of senior staff behaviour. One hypothesis for this perceived resistance is that; undergraduates are students rather than staff and so are accustomed with needing to engage in tasks differently to more senior clinicians, because they are involved in a learning process. Whilst SpR training is meant to prepare the individual for a senior post, with part of this process involving questioning and appraising the behaviour of senior colleagues. However, the SHO group may be the most vulnerable to the influence of senior colleagues as they are in a position where look to emulate their behaviours, but do not feel they are in a position to question these behaviours.

8.2.3 Clinic Type Performance

A significant association between the type of clinic attended and completion of a CARE Tool was found ($p = 0.04$). This confirms what was already suspected during the project; that behaviours on different clinics varied, likely due to the differing demands of these clinics and the established processes involved. It is noticeable that a group of clinics; consultant clinics, treatment sessions and sedation, showed considerable consistency in results. Given the flow of patients through the department, an initial consultation followed by treatment, our expectation is that behaviours on the consultant clinics are having knock on impacts. The expectation would be that a CARE Tool would be completed at the consultant clinic visit as part of the treatment planning exercise. This was the driver for the number of the change concepts being directed at behaviour on the consultant clinics.

One of the areas the PCPCS was developed to cover was the casual clinics along with paediatric assessment; with the results from both clinics appearing to be affected by the loss of PCPCS supplies. Given the emergency nature of the casual clinic and resultant variety of potential patient presentations, we were

aware of the difficulty of developing a single standardised CARE tool for this clinic. The trauma stamp is another CARE tool commonly used on the casual clinic. Given the potential complexity of patient presentations on this clinic we were aware that not every potential presentation would be fully addressed by even this combination of CARE tools. As we were yet to achieve consistency on the routine clinics, it was elected to postpone the management of the additional complexity of this clinic till a later point.

8.2.4 Barriers to Improvement

There was no disagreement about the necessity of a caries risk assessment or effectiveness of caries prevention amongst clinicians. However, the 2007 departmental survey shows that, these were likely done in an ad hoc fashion and not routinely documented. When investigated, it would invariably be reported that these were not documented due to time pressures and/or memory failings. By undertaking this study it was intended to help address these issues. Both staff surveys identified workloads as an area of concern, though fully addressing the many demands on clinician's time was beyond the scope of this project. Therefore, every effort was made to ensure that any impact on workloads was minimised and changes, where at all possible, speeded up working. An example of this is the development of the PCPCS; by using this tool clinicians quickly generated a letter back to the referring practitioner without the need for additional secretarial support or time for dictation, whilst still producing a documented CRA and preventive plan.

Based on Rogers model of innovation diffusion, we likely started with an advantage on the innovation-decision process for the individuals within the department (Rogers, 2003). There was already significant knowledge about CRA and caries prevention and amongst the peer group within the department it was considered important. However, the CARE tools did represent a new innovation and so the full decision process would have been required before individuals would actively use them. We had a supportive peer environment for CRA and prevention and this is likely to have been a positive facilitator in the decision process.

We did not have the authority to impose the decision to use the CARE tools; we were reliant on a mix of collective and individual decisions of individual team members to use them, noted by Rogers to be amongst the slowest forms of innovation adoption. This lack of authority also meant that we could not compel others to become involved in the project or instruct changes beyond the limited direct control of the project.

This is particularly evidence in the problems encountered getting medical records staff to place a CARE sheet in new case notes (See 7.2.4 Barriers Identified, Page 138). Though we did receive initial support from the medical records team, this was not consistent. This lack of consistency led to resentment amongst clinical staff and had the potential to combine with other problems clinical staff were regularly having with medical records. Given that adequately addressing all these issues was beyond the scope of the CARE project, it was decided to develop alternatives avoiding the participation of medical records, to avoid the project becoming inextricably linked to the problems with medical records.

The majority of identified barrier to improvement during the project could be related to the knowledge and environmental constraints behaviour domains (See Table 42, Page 169). That these behaviour domains should feature so frequently is unsurprising given that the examples relating to these two domains relate to very fundamental issues (See Appendix 2). In relation to knowledge, the CARE tools were designed to be as self-explanatory as possible; however, a basic level of knowledge was required for their intended use. Whilst in relation to environmental constraints, if a CARE tool was not available, for example the extended absence of the PCPCS, then negative impact on the desired behaviour is inevitable.

That such a significant amount of time during the project had to be devoted to addressing these two behaviour domains does indicate their importance, however, is also unfortunate, as it limited our ability to explore the full range of domains. Out of the 12 behaviour domains identified by Michie *et al.* only 6 had interventions targeted at them, suggesting that there was a number of other areas that could have been explored for improvement. Fundamentally, we aimed to achieve a culture change within the department, so that completion of

a CARE tool would be the expected norm. There was no single change which would lead to such a culture change; rather the intention was that a combination of multiple reinforcing changes and time would lead to the intended shift in ethos.

8.2.5 Change Concepts and Knowledge Gained

As discussed above, a level of knowledge was required to participate in the project and so a significant number of the change concepts introduced related to educating the staff with the knowledge they required to participate in the project. As staffing within the department, particularly amongst the SHOs, is relatively dynamic; knowledge once gained, could not be assumed to be maintained and when staff changed the knowledge went with them. Knowledge needed to be continually reinforced, which placed a burden of vigilance on the working group. However, education alone was of limited success, it does not address the initial barriers of memory and time constraints as staff still needed to remember to complete a CARE tool. In order to achieve our aim we required changes that went beyond education.

We attempted to model our change on the success of the PCPCS on the paediatric assessment clinic. Here a nurse would complete the initial patient and referrer demographics; the clinician would complete the clinical details during the consultation and at the end a copy would be given to the parent, and the clinician would place a copy in the case notes and the nurse would organise for the third copy to be posted to the referring practitioner. This was done as an expected matter of routine on the clinics and explained the high level of results both on the paediatric assessment clinic and for the hospital practitioners who worked on them.

As mentioned previously the consultant clinics were a priority area. If the same level of consistency on the paediatric assessment clinic could be achieved here, then the results should filter through to the other treatment clinics. Our first change to attempt to replicate this success was to have the nursing staff start the completion of a CARE sheet by taking patient's heights and weights on arrival to the clinic. This worked well, as it increased the professional status of the nursing staff as they no longer simply fetched patients for the clinicians;

instead they started the process of collecting clinically useful information. Also it integrated well into a health promotion ethos, allowing body mass index to be calculated for the detection of underweight and obese children. Not only was this taking a common risk factor approach to health promotion as advocated by Watt, it led to the development of further health promotion projects within the department (Watt, 2005). The time impact of this change was minimal, the scales and height measure were both portable, so could be conveniently positioned on the path the patient would naturally take on entry to the clinic, meaning the whole process only took a minimum of time.

The next change directed at this clinic was the revision of the CARE sheet. At the start of the project, changes were made to the CARE sheet with the intention of increasing completion rates. However, feedback from the clinicians was that some elements were off putting, so a subsequent round of revision was undertaken. The main issue reported was that the clinicians found the structured treatment plan with default options, overly restrictive. This was leading some clinicians to writing a treatment plan in the patient's general notes and then transcribing it onto the CARE sheet. This replication of effort was onerous and off putting, hampering completion rates. The rationale for originally placing default option on the treatment plan has been previously discussed (See 5.6 CARE Toolkit, Page 105).

Based on this feedback it was decided to remove them along with the itemisation of the treatment plan. Instead the new version was designed to be as similar to current practice as possible, with a free text area given for the treatment plan. To maximise the size of this free text area it was also decided to remove the radiograph section from the CARE sheet, as this was felt to be superfluous. These changes increased the compatibility and reduced the complexity of the CARE sheet, based on Rogers characteristics of innovations these changes would improve uptake (Rogers, 2003).

There remained a need for a further feedback step within the process of completing a CARE sheet on the consultant clinic. The final change to the revised CARE sheet was the addition of an area for a consultant to sign off the treatment plan. The intention was that at the end of consultant clinics, all the treatment plans would be reviewed and signed by the consultant, a final check

to ensure a CARE sheet had been completed. We introduced a “wash up” at the end of consultant clinic, where cases could be discussed amongst the clinician and CARE sheets signed off by consultants. This was often informally done already, so our expectation was that this would be compatible for ready implemented.

During the PDSA testing of this change, we found that junior clinicians liked the concept as an additional educational opportunity. Unfortunately, the availability of time at the end of clinics was found to be an issue. Often consultant clinics ran right to the end of the session and encroached into lunch or the end of the working day. This resulted in a reluctance to spend an additional time discussing cases. As an alternative, performing the “wash up” process in an on-going fashion during the clinic, avoiding the need for additional time at the end of clinic, was attempted. However, this ad hoc fashion made it difficult to ensure the wash process had been comprehensively completed for every patient, our initial aim for introducing the change.

8.2.6 Dissemination of Results

Every opportunity was taken to raise the profile of the CARE project, both within the department and beyond. Initially it was found that people had difficulty in differentiating the methods used in the CARE project, from conventional audit; though as time progressed our ability to succinctly articulate the differences improved. Also as the project progress dissemination was used as another avenue for encouraging SHO participation with the project. If they were going to stand up and talk about the project, they needed to have a level of understanding about what was happening.

For improvement to be sustained change is required to the social culture the change is being implemented in. For QI projects the main influence that can be placed on a system to induce change, is changes in process. Change in culture is more fundamental, involving the values of the individual's within the system. This is difficult to influence directly, as it is determined by the intrinsic motivation of individuals to perform a task. *Deci et al.*'s review on the topic of intrinsic motivation and external rewards indicates that care must be taken when attempting to modify intrinsic motivation (Deci et al., 1999). External

rewards can improve performance in the short term, but once removed have been shown to be detrimental to intrinsic motivation.

However, if we aim to achieve a change in social culture an attempt must be made to modulate the intrinsic motivation of the individuals— albeit carefully. Our primary instrument for achieving this was through positive feedback. This form of external reward has been shown to enhance intrinsic motivation, as long as it is delivered in a non-controlling fashion. The positive feedback was delivered in the form of dissemination of the results of the run chart and the various prevention audits, as we felt that achieving and maintaining positive results would have a positive impact on intrinsic motivation without being seen as overly controlling. Table 45 (See Page 177) shows that this dissemination was done by frequent presentations, along with regular feedback to departmental staff via emails and by the departmental QI notice board. The departmental QI notice board is prominently placed as staff and patients enter the clinic. The intention is that this public display of performance would further influence the desired culture change.

8.2.7 Future Issues of Quality Improvement and Healthcare

One of the biggest challenges facing healthcare services in the UK and across the world is how to cope with financial constraint in face of ever increasing demands for healthcare (Hunter, 2010). Services will be required to do “more with less”; in terms of terms of delivering the most effective care in the most efficient fashion. The philosophy and methodologies of quality improvement would be an obvious set of tools to aid in achieving this goal. However, this twin aim, to deliver the most effective care, whilst at the same time the most efficient; has already and will continue to come into conflict; in areas such as marginal cost-benefit (See 1.3.1.4 Ethics and Quality Improvement, Page 36). These challenges require the differing perspectives of different stakeholders in the healthcare service to be resolved (See 1.3.1 What is Quality Improvement? Page 30); so ideally they all are working towards a common aim, or at least not antagonistically competing.

The scope to make care more effective and less wasteful is there. McGlynn *et al.* reported that patients with chronic diseases in the United States received

only 56.1% of the care recommended for management of their condition (McGlynn et al., 2003). Many of these chronic conditions will have long term, potentially expensive, complications that could be avoided with rigorous application of, comparatively inexpensive, preventive care. If quality improvement methods can be developed to address this gap, potentially significant long term savings can be realised.

8.3 Caries Risk Assessment and Prevention

In order to address the noted limitations of selection bias in the “With and Without CARE Tool” surveys, and a very limited sample of 25 consecutive patients being used in the 2007 departmental survey, a larger survey was carried out on a random sample of all patients who attended the department in 2007 and 2010 to assess the impact of the CARE project on preventive care. This had to be in the nature of a retrospective evaluation, as it would be impossible to maintain a control group not being impacted by the QI interventions within the same department. There is the possibility that other changes between the two years may have been responsible for the change in results, for instance the publication of new SDCEP guidelines in 2010, or the changes in staff throughout the project.

The results showed that in 6 out of the 7 preventive interventions assessed there was a significant improvement in 2010 compared to 2007 (See 7.4.7.2 Results - 2007 v 2010 Survey, Page 163). The only intervention that did not reach a significant level of improvement was fissure sealants on first permanent molars. Along with the improvement in overall scores, there is a suggestion of an increased level of consistency in the figures from 2010, with the difference between the highest score and lowest scoring interventions markedly lower than in the 2007 results. Throughout the prevention surveys, the criteria used this study was intended to reflect the level of preventive care expected to be delivered to every child regardless of their overall CRA. The rationale for this was every child should be meeting these standards, and as such they could be considered universal. If during the project these universal standards had been consistently achieved, then more detailed work examining whether children received appropriate personalised preventive plans based on their CRA would have been appropriate.

In summary, these results are suggestive that the process behind the delivery of preventive interventions became more controlled in 2010 and less haphazard. An underlying hypothesis of the CARE project has been that the delivery of caries prevention represents a system of care (See Figure 50).



Figure 50 Conceptual Process of Preventive Care Delivery

Riley *et al.* have reported that practitioners who undertake a CRA for adult patients are more likely to deliver preventive care (Riley et al., 2010). The results of this survey offer some support for this relationship also be applicable to the treatment of children. However, further research would be required to fully establish whether this relationship truly exists or not.

Chapter 9 – Conclusions

9.1 Primary Aim

What were we trying to improve?

The completion of a documented caries risk assessment for all patients attending the department of paediatric dentistry.

Why did we need to improve?

A caries risk assessment is the crucial first step in determining the caries preventive care our patients should receive. An initial audit found that a caries risk assessment was not being routinely documented.

Where did the improvement occur?

Improvement was seen on all the clinics within the department of paediatric dentistry. The greatest and most consistent improvement was seen on the paediatric assessment clinic; when the PCPCS was available.

When did the improvement occur?

Throughout the 25 months of the study improvement efforts were undertaken to address a number of barriers. However, by the end of the period documented we were yet to consistently achieve our 95% target.

How much did we improve?

Prior to instigating the CARE project, rates of CRA documentation were effectively nil. This being shown in the both the 2007 departmental prevention audit and the 2007 versus 2010 prevention audit. Changes instituted by the CARE project has resulted in rates of CRA documentation consistently greater than 50%. Whilst a positive shift in performance is present in the last three months of the study (See 7.4.1 Run Chart, Page 151), further work is required to consistently achieve our 95% target.

9.2 Secondary Aim

The prevention audits provided a useful adjunct to the on-going QI work relating to CRA documentation; especially as it was beyond the scope of this project to monitor our ideal outcome measure of new carious lesions. All of the prevention surveys carried out during the project showed that the CARE project improved documentation of delivery of prevention. With the 2007 v 2010 survey finding significant improvement in 6 out of 7 preventive interventions following the implementation of the CARE project. Whilst room for further improvement of prevention exists, this finding supports our conceptual hypothesis of the process behind that delivery of preventive care, with improvement in caries risk assessment feeding through to improvements in preventive care. Given that the delivery of prevention appears to be an interrelated process; future QI efforts targeting a specific aspect of preventive care look likely to further improve all related elements.

Chapter 10 – Future Recommendations

The intention remains to continue to work towards achieving our aim of every child attending the department having a documented caries risk assessment. Achieving this will require the maintenance of the methods instigated by the CARE project, regarding continual monitoring of performance and using PDSA cycles to develop and test change. Therefore, the CARE project continues beyond the period documented here (See Table 47). Changes implemented subsequently have included the development of a standardised new patient assessment, which contains the elements of the CARE sheet, the impact of which is presently being evaluated.

Table 47 Further Dissemination of Work

Date	Event (Method of Presentation)	Presenter	Topic Covered
September 2011	BSPD (Oral)	AK	Plenary session presentation discussing the implementation of QI methods in clinical practice.
September 2011	BSPD (Poster)	SHO	Evaluation of sugar free medicines advice
September 2011	BSPD (Poster)	SHO	Results of staff group performance during the CARE project
September 2011	BSPD (Oral)	CDS Practitioners	Audit of preventive care standards in undergraduate clinics at GDH and outreach
November 2011	RCPSG Triennial (Poster)	CDS Practitioner	Performance of undergraduate clinics in relation to fluoride varnish application HEAT target
November 2011	RCPSG Triennial (Poster)	CDS Practitioner	Audit of preventive care standards in undergraduate clinics

Chapter 11 – Summary

To the best of our knowledge this work represents one of the first reports on the utilisation of modern QI methodologies in clinical oral health practice. Whilst this entailed a significant learning curve; we found that the knowledge and practices utilised in other healthcare fields could successfully be applied in oral healthcare. Some of the challenges faced will be unique to the particular clinical environment described. Still, much of the knowledge gained can be generalised for application elsewhere; particularly as many of the issues relating to staff training, administrative practices or intervention development will be universal.

This project demonstrates that QI methodologies can positively influence behaviours relating to caries risk assessment and preventive care. Given an aging population and global economic difficulties, there are significant pressures on healthcare services to deliver efficiency savings in relation to cost. Rather than arbitrarily cutting costs, QI methods afford a more positive approach; ensuring services are delivering care consistent with best evidence. If we can routinely apply what is known to be best evidence; patients should experience better outcomes; freeing resources for the future.

Appendices

1 Literature Search

Searches carried out 15/04/10 querying Ovid Medline® 1946 to April Week 2 2010 and Embase 1974 to 2010 Week 11.

Search #1 - Caries Prevention in Children

Limit (Limit (((child or children or childhood or paediatric or pediatric* or adolescen* or preschool or infan* or school age or schoolage or teen* or youth* or toddler*).tw.) and ((dental or tooth or teeth).tw.) and ((caries or decay).tw.) and ((effective* or efficacy or evaluat* or trial* or random* or blind* or meta?analysis or guideline*).ti,ab.) and ((toothbrush* or cariostatic or oral hygiene or fluorid* or mouthwash* or educat* or prevent* or promot* or prophyla* or radiograph* or sealant*).ti.)) to yr="2000 -Current") to "review articles" [Limit not valid in EMBASE; records were retained]*

Search Themes

- Child patient
- Teeth
- Caries
- Effectiveness/Evaluation/Trial/Guideline
- Caries Preventive Measures
- Year 2000 - Current
- Review Articles

Number of Results: **148**

Exclusion Criteria

- Remove duplicates
- Articles not relating to studies relating to Humans
- Articles relating to in vitro studies
- Articles relating to epidemiological surveys
- Articles relating to general medical practice
- Articles relating to water fluoridation
- Articles not in the English Language
- Articles on Diagnostic Tools
- Articles on Caries Prevention in Children whose results are not generalizable to the general child population of Scotland
- Articles on not relating to preventive interventions in Children

Number after review of titles and abstracts: **87**

Search #2 - Caries Risk Assessment in Children

Limit (Limit (Limit (remove duplicates from (((child or children or childhood or paediatric or pediatric* or adolescen* or preschool or infan* or school age or schoolage or teen* or youth* or toddler*).tw.) and ((dental or tooth or teeth).tw.) and ((caries or decay).tw.) and (((risk* adj5 assess*).tw.) or ((risk* adj5 factor*).tw.) or ((risk* adj5 evaluat*).tw.) or (susceptib*.tw.)))) to english language) to yr="2000 -Current") to "review articles" [Limit not valid in EMBASE; records were retained]*

Search Themes

- Child patient
- Teeth
- Caries
- Risk factors/Risk Assessment/Susceptibility
- English language
- Year 2000 - Current
- Review Articles

Number of Results: 117

Exclusion Criteria

- Remove duplicates
- Remove articles relating to general health
- Remove articles relating to dental restorations
- Remove articles relating to risk factor for dental conditions, not caries
- Articles relating to general medical practice
- Articles on not relating to preventive interventions or caries risk assessment in Children
- Articles on Caries Prevention in Children whose results are not generalizable to the general child population of Scotland

Number after review of titles and abstracts: **81**

Search #3 - Quality Improvement

Limit (limit (remove duplicates from ((health?care.m_titl.) and (((continuous adj2 improv*) or (guideline* adj2 adher*) or (quality adj2 assur*) or audit* or (quality adj2 manag*) or (quality adj2 care) or (continuous adj2 improv*) or (quality adj2 improv*)).ti.))) to english language) to yr="2000 -Current"*

Search Themes

- Health Care (in title)
- Continuous Improvement/Guidelines/Quality Assurance/Quality Management/Quality Care/Quality Improvement
- English language
- Year 2000 - Current

Number of Results: 172

Exclusion Criteria

- Remove duplicates
- News articles
- Articles relating to conventional clinical audit
- Articles relating to implementation of specific IT systems
- Articles relating to issues not generalizable to UK healthcare systems
- Articles not relating to clinical quality improvement

Number after review of titles and abstracts: **114**

Search #4 - Prevalence of Caries in Scotland

Remove duplicates from (((child or children or childhood or paediatric or pediatric* or adolescen* or preschool or infan* or school age or schoolage or teen* or youth* or toddler*).tw.) and ((dental or tooth or teeth).tw.) and ((caries or decay).tw.) and ((prevalen*.tw.) or (epidemiolog*.tw.))) and ((scot* or glasgow or edinburgh or dundee or aberdeen or lothian* or lanark* or tayside).tw.))*

Search Themes

- Children
- Teeth
- Caries
- Prevalence/Epidemiology
- Scotland

Number of Results: 22

Exclusion Criteria

- Articles relating to caries diagnosis
- Articles relating to water fluoridation

Number after review of titles and abstracts: **19**

Search #5 - Oral Health Promotion in Children

(Health Promotion/) and *(National Health Programs/)* and *((Dental Care for Children/)* or *((Child/)* or *(Child, Preschool/))* and *(Dental Caries/))*

Search Themes

- Health Promotion (Keyword)
- National Health Programs (Keyword)
- Dental Care for Children (Keyword)
- Child (Keyword)
- Child, Preschool (Keyword)
- Dental Caries (Keyword)

Number of Results: 15

Exclusion Criteria

- Articles relating to issues not generalizable to UK healthcare systems

Number after review of titles and abstracts: **12**

Search #6 - Oral Health Promotion in Children

((National Health Programs/) or *(National Health Program*.tw.)*) and *((dental or tooth or teeth).tw.)* and *((caries or decay).tw.)*) and *((Dental Caries/)* or *((dental or tooth or teeth).tw.)* and *((caries or decay).tw.))*) and *((child or children or childhood or paediatric* or pediatric* or adolescen* or preschool or infan* or school age or schoolage or teen* or youth* or toddler*).tw.)* or *((Child/)* or *(Child, Preschool/))*

Search Themes:

- National Health Programs
- Teeth
- Caries
- Children

Number of Results: 33

Exclusion criteria:

- Articles relating to issues not generalizable to UK healthcare systems
- Articles not in English
- Articles related to in vitro studies
- Articles not related to interventions to reduce caries in children
- Articles relating to water fluoridation

Number after review of titles and abstracts: **26**

2 Behaviour Domains

Adapted from (Michie et al., 2005)

Behaviour Domain	Constructs	Examples
Knowledge	Knowledge	Do they know about the guideline?
	Knowledge about condition/scientific rationale	What do they think the evidence is?
	Procedural knowledge	Do they know they should be doing x? Do they know why they should be doing x?
Skills	Skills	Do they know how to do x?
	Competence / ability / skill assessment	How easy or difficult do they find performing x to the required standard in the required context?
	Practice / skill development	
	Interpersonal skills	
	Coping strategies	
Social/Professional role and identity	Identity	What is the purpose of the guidelines?
	Professional identity / boundaries / role	What do they think about the credibility of the source?
	Group / social identity	Do they think guidelines should determine their behaviour?
	Social / group norms	Is doing x compatible or in conflict with professional standards/identity?
	Alienation / organisational commitment	Would this be true for all professional groups involved?

Beliefs about capabilities	Self-efficacy	How difficult or easy is it for them to do x?
	Control – of behaviour and material and social environment	What problems have they encountered?
	Perceived competence	What would help them?
	Self-confidence / professional confidence	How confident are they that they can do x despite the difficulties?
	Empowerment	
	Self-esteem	How capable are they of maintaining x?
	Perceived behavioural control	How well equipped/comfortable do they feel to do x?
	Optimism / pessimism	
Beliefs about consequences	Outcome expectancies	What do they think will happen if they do x?
	Anticipated regret	
	Appraisal / evaluation / review	What are the costs of x and what are the costs of the consequences of x?
	Consequents	
	Attitudes	Do benefits of doing x outweigh the costs?
	Contingencies	
	Reinforcement / punishment / consequences	How will they feel if they do/don't do x?
	Incentives / rewards	Does the evidence suggest that doing x is a good thing?
	Beliefs	
	Unrealistic optimism	
	Salient events / sensitisation / critical incidents	
	Characteristics of outcome expectancies	

Motivation and goals	<p>Intention; stability of intention / certainty of intention</p> <p>Goals – target setting, priority</p> <p>Intrinsic motivation</p> <p>Commitment</p> <p>Distal and proximal goals</p>	<p>How much do they want to do x?</p> <p>How much do they feel they need to do x?</p> <p>Are there other things they want to do or achieve that might interfere with x?</p> <p>Does the guideline conflict with others?</p> <p>Are there incentives to do x?</p>
Memory, attention and decision processes	<p>Memory</p> <p>Attention</p> <p>Attention control</p> <p>Decision making</p>	<p>Is x something they usually do?</p> <p>Will they think to do x?</p> <p>How much attention will they have to pay to do x?</p> <p>Will they remember to do x? How?</p> <p>Might they decide not to do x?</p>
Environmental context and resources	<p>Resources / material resources</p> <p>Person & environment interaction</p> <p>Knowledge of task environment</p>	<p>To what extent do physical or resource factors facilitate or hinder x?</p> <p>Are there competing tasks and time constraints?</p> <p>Are the necessary resources available to those expected to undertake x?</p>

Social influences	Social support Social / group norms Organisational development Leadership Team working Group conformity Organisational climate / culture Social pressure Power / hierarchy Professional boundaries Management commitment Supervision Inter-group conflict Champions	To what extent do social influences facilitate or hinder x? Will they observe other doing x?
Emotion	Affect Stress Anticipated regret Fear Burn-out Cognitive overload / tiredness Threat Positive / negative affect Anxiety / depression	Do doing x evoke an emotional response? To what extent do emotional factors facilitate or hinder x? How does emotion affect x?

Behavioural regulation	Goal / target setting Implementation intention Action planning Self-monitoring Goal priority Generating alternatives Feedback Project management Barriers and facilitators	What preparatory steps are needed to do x? Are there procedures or ways of working that encourage x?
Nature of the behaviours	Routine / automatic / habit Breaking habit Direct experience / past behaviour Representation of tasks	Who needs to do what differently, when, where, how often and with whom? How do they know whether the behaviour has happened? What do they currently do? Is this a new behaviour or an existing behaviour that needs to become a habit? Can the context be used to prompt the new behaviour? How long are changes going to take? Are there systems for maintaining long term change?

3 NHS Scotland Quality Strategy Outcome Measures

- Healthcare experience
- Staff experience
- Staff attendance
- Healthcare associated infections
- Emergency admissions
- Adverse events
- Hospital Standardised Mortality Rate
- Proportion of people who live beyond 75 years
- Patient reported outcomes
- Patient experience of access
- Self assessed general health
- Percentage of last 12 months of life spent in preferred place of care

4 A Pilot Improvement Project in Hospital-Based Oral Healthcare - Improving Caries Risk Assessment Documentation

A pilot improvement project in hospital-based oral healthcare: improving caries risk assessment documentation

A. J. Keightley,¹ S. M. Lucey,² J. Leitch,³ R. C. Lloyd⁴ and C. Campbell⁵

IN BRIEF

- A direct clinical example of translation of evidence into practice using contemporary improvement methodologies.
- By regular monitoring and feedback on performance, barriers to improvement can be identified and addressed.
- Targeting documentation of a caries risk assessment delivered subsequent improvement in documentation of delivery of caries prevention interventions.

RESEARCH

Objective To evaluate the impact of a continuous improvement project to improve completion of a caries risk assessment (CRA) and to assess its impact on delivery of dental caries prevention. **Design** Single centre clinical improvement project. **Setting** A paediatric dental department within a UK dental hospital over the course of 2008–2009. **Subjects (materials) and methods** Continuous monitoring of documentation of a CRA was instigated and results fed back to clinicians. Tools were developed to structure the process of CRA. After six months of intervention, a comparison of preventive care to a pre-intervention sample was undertaken. **Main outcome measures** The main outcome measure was completion of a CRA. Comparison was also made with pre-intervention data on levels of preventive care received. **Results** Over the 12 month project the mean rate of CRA completion improved from 30% over the first 6 months to 73% in the second 6 months. Compared to the pre-intervention sample, all items of the caries prevention package had improved, with delivery of tooth-paste strength advice (16% vs 60%, $p = 0.001$) and diet advice (32% vs 70%, $p = 0.004$) improving significantly. **Conclusion** By targeting and improving CRA completion the quality of preventive care delivered has also significantly improved.

INTRODUCTION

The white paper 'The new NHS: modern, dependable' (1997) stated '*...that quality is at the core*' of the future of the National Health Service (NHS).¹ This position reflected a shift in the NHS policy, to emphasise that quality improvement throughout the UK should be occurring as it had been witnessed elsewhere in the world.² Since then, the literature on improving the quality of healthcare has expanded rapidly, but as of yet the literature concerning quality improvement in oral healthcare remains limited.

Oral diseases are endemic throughout the world, with dental caries being the

most prevalent, yet dental caries is highly preventable.³ Among children in Scotland epidemiological studies have found that the distribution of dental caries appears to be concentrated in particular 'high risk' sections of the population. The 2010 National Dental Inspection Programme found 64% of 5–6-year-old children in Scotland being caries free, however, 8% of the children had 50% of the dental caries.⁴ Within Scotland 'operations on teeth including simple extraction' were the largest single reason for an elective hospital admission for children under the age of 15 in 2007/2008, accounting for 23.4% of the total.⁵

The department of paediatric dentistry in Glasgow Dental Hospital and School is a secondary referral centre, which accepts patients from the whole of the west of Scotland. This area covers a diverse range of patients, from the most deprived urban areas in the UK, to the most isolated rural island communities. Patients are treated up to the age of 16 years on referral. Reasons for referral include complex oral and/or general health conditions, dental trauma, and dental anxiety/phobia. Patients may require treatment under inhalational or

IV sedation, or general anaesthesia. In the period from October 2008 to October 2009, 8,794 patients attended the department for consultations or treatment on an outpatient basis, with 2,625 requiring treatment under general anaesthetic.

The evidence base to show there are effective interventions for preventing dental caries is well established and several clinical guidelines have been published in the UK on the subject.^{6–9} These guidelines recommend dentists perform a caries risk assessment (CRA) for every patient and personalise preventive care appropriately. Results published by another unit in Scotland have shown poor levels of documentation of CRA.¹⁰ These results supported the need to monitor and if needed undertake an improvement project to increase the level of documented CRA and to ensure that effective preventive care was delivered.

This report documents our experiences of introducing a health improvement project to the department, under the title of Caries Assessment Risk Evaluation (CARE). This project incorporated the introduction of a CARE toolset, to aid in implementing a CRA and preventive

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Fig. 1 The caries risk assessment and prevention planning pro forma

Fig. 3 Primary care provider communication sheet

plan. The primary aim was to have at least 80% of the patients attending the department have a fully documented CRA by June 2009. The secondary aim was to evaluate whether improving CRA documentation improved the preventive care patients received. The project began in August 2008.

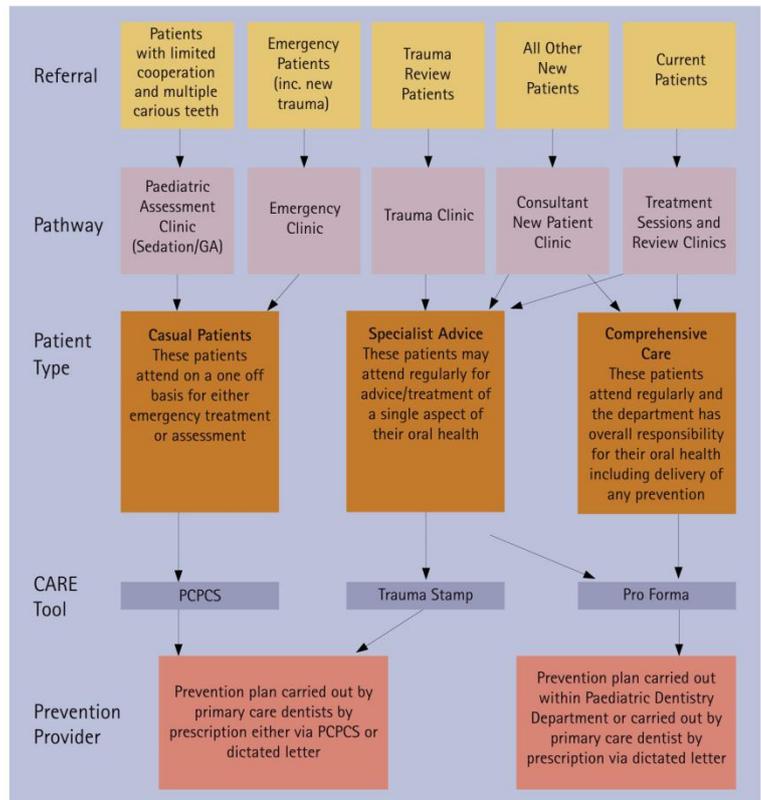


Fig. 2 Final patient flow through CARE project process

TOOTH				
SINUS				
COLOUR				
TTP				
MOBILITY				
EPT				
ECL				
P. NOTE				
RADIOGRAPH				
CARIES RISK				

Fig. 4 Updated trauma stamp

METHODS

Study design and initial intervention

Following the results of a 2007 departmental audit (baseline), which found an unacceptably low level of documentation of CRA and subsequent delivery of prevention, a working group was formed. The aim of this working group was to lead a quality

improvement project to improve documentation of delivery of both CRA and prevention. This working group oversaw the project, led by a consultant in paediatric dentistry and involving postgraduate dental trainees. The working group met regularly during the course of the project, and structured its work around the PDSA (Plan-Do-Study-Act) improvement model.¹¹ The initial improvement aim was

to target the documented completion of a CRA. Once the patient's caries risk status is determined, an evidence-based dental caries prevention package can be devised.¹²⁻¹⁵

The first intervention was revising a pre-existing CRA and prevention planning pro forma that was already in use on the undergraduate teaching clinics. This involved consultation with all clinical staff, before a revised pro forma was launched in September 2008 (Fig. 1). To increase uptake, the medical records department agreed to place this pro forma into all new paediatric patient case notes. For patients already attending the department, the pro forma was to be completed and added to the notes by the dentist at their next appointment.

Data collection

A judgement sample was collected by an investigator who would select two patient charts at the end of every morning and afternoon session. A cross section of all clinics within the department was represented. The notes were examined and for a positive result to be recorded an overall CRA level had to be noted. This gave a total of 20 samples over the course of a week, and the process was carried out every second week. This data collection was carried out from September 2008 until July 2009.

Statistical methods

The primary statistical method used to analyse the data relating to CRA completion rates was statistical process control (SPC).¹⁶ SPC comes from the work of Walter Shewhart in the 1920s in relation to manufacturing, as a method for detecting whether a system was acting under common or special cause variation. Shewhart identified that even a stable system will produce a range of results purely due to random chance and should therefore be considered acting under common cause variation. In contrast, if a system is producing results beyond those attributable to random effect, these systems should be considered to be acting under the influence of special cause. The specific SPC tool used was a type of control chart called the p-chart (percentage chart), which determined if the interventions produced significant changes in the measures. The control chart was annotated as the project progressed to indicate

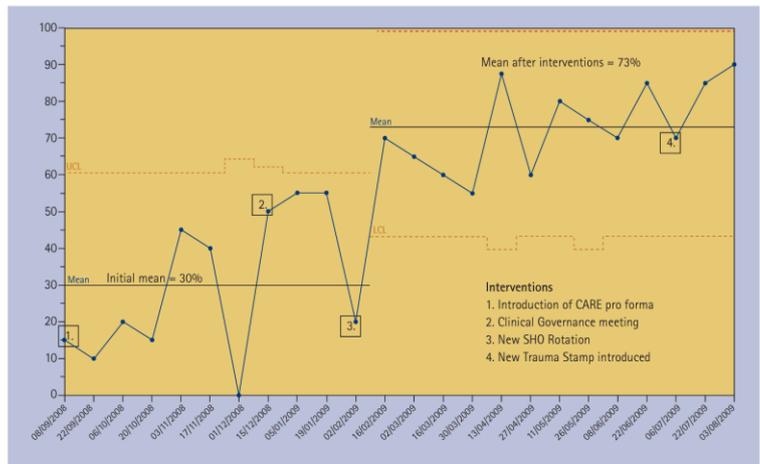


Fig. 5 CARE tool uptake data

where the interventions (or changes) were implemented and if they had the intended impact. The working group would regularly disseminate the results by displaying charts on the clinic, emailing them to all staff and by regularly reporting to departmental meetings.

In January 2009, a comparison was made with the 2007 audit data to determine if the project had statistically significant impacts on preventive care received by patients. Case notes of 40 patients were reviewed in two groups; 20 patients, who were known to have a completed pro forma in October 2008, compared with 20 patients known not to have a completed pro forma. It was expected that by reviewing the case notes for patients who had attended four months previously, any preventive care planned would have then been delivered. The results were then tabulated in Minitab 15 (Minitab Inc., State College, Pennsylvania, USA) and analysed using a two-sample t-test. No power calculation was carried out for this analysis due to the pilot nature of this project.

RESULTS

PDSA cycles and change concepts

PDSA cycles were carried out on a regular basis to test the effectiveness of the interventions. The major changes instigated by this approach are shown in Table 1. The process developed for ensuring patients had a CRA and that prevention was carried out in the most appropriate setting is demonstrated in Figure 2, while examples

of the tools developed to assist in documenting a CRA in each setting are given in Figures 3 and 4.

Uptake of CRA

Over the course of the project 464 patient charts were reviewed and the key measure, percentage with a completed CRA, was plotted on a SPC p-chart (Fig. 5). The left side of Figure 5 displays the baseline period with a mean of only 30% of the patients seen in the department having a completed CRA. Even though the baseline period reflects considerable variation in the data, there are no special causes detectable in the data and it is therefore likely that the system is acting under common cause variation. This means that the baseline period is stable and predictable within limits (that is, the process on the average would continue to produce about 30% of the patients having a completed caries risk assessment tool and utilisation of the tool could range from zero to around 60%). Since the target was to have 80% or more utilising the CRA tool, this performance was considered stable and predictable, but unacceptable.

The annotations on Figure 5 highlight the points of the key interventions during the project. Point 1 is the first measurement taken the week after the introduction of the revised CRA pro forma at the beginning of September 2008. With continued feedback and encouragement this produced an improvement from the initial 30% to around 40%. Unfortunately at point 2 significant fall was detected at the

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beginning of December 2008. This was discussed at the departmental clinical governance meeting the following week, with the main reason identified for the fall being the multiple staff absences that week due to illness and annual leave. At the meeting it was suggested that nursing staff prepare the pro forma to improve work flow. At point 3, at the beginning of February, the junior trainees complete their six month rotation and change department. A fall in CRA completion was reflected in the results coinciding with this. It was found that the new trainees were not familiar with the CARE project, and so a training session was held. Between points 3 and 4 the other CRA tools (Figs 3 and 4) were developed as detailed in Table 1.

The right side of Figure 5 shows the performance of the key measure as the change concepts (Table 1) were introduced. While there are numerous tests to determine statistically significant movement on a control chart,¹⁶ the one that is shown in Figure 5 is a shift in the process performance. A shift in process is determined by detecting a run of eight or more data points above the baseline mean. In our case the evidence of a shift is very strong since 13 data points are all above the baseline mean of 30%. The probability of this happening by chance would be extremely rare. The new uptake of CRA process average is 73% with the control limits predicting that the variation in the new process could be between roughly 45% and 100%.

Impact on preventive care

The result of the comparison of preventive care received by 2009 patients with and without a completed CARE tool, compared to the data from the 2007 audit is shown in Figure 6. Within all categories, the 2009 patients with a completed CARE tool received more elements of the prevention package. The 2009 patients who did not have a CARE tool actually received less prevention than the 2007 sample.

The results from the 2009 patients who did have a CARE tool completed were compared to the 2007 patients using a two-sample t-test using Minitab 15 (Minitab Inc., State College, Pennsylvania, USA). The results of this analysis (Table 2) show that the levels of provision of toothpaste strength advice (estimate for difference = 44%, p = 0.001) and diet advice

Date	Problem	Identified cause	Change implemented
December 2008	Monitoring identified a fall in pro forma uptake to 0%	Particular week had staffing difficulties due to multiple staff absences	Issues discussed at subsequent departmental clinical governance meeting
February 2009	Fall in completion of pro forma	Junior postgraduate trainees rotate departments on 01 February, new trainees had not received training relating to the project in their departmental induction	Training needs for new trainees addressed and CARE project training manual created to be used in subsequent staff inductions
February 2009 – May 2009	Identified low completion of CRA along with poor communication for patients attending for assessment for extractions under general anaesthesia and for patients attending as one off emergencies on the casual clinic	The working practices on these clinics along with type of patients made pro forma unsuitable	Primary care provider communication sheet (PCPCS) was designed in the SBAR style (Fig. 3). ¹⁷ A pilot study was carried out before being formally introduced in May 2009.
June 2009	Identified trauma patients as a group with low rate of completion of pro forma	Staff working with these patients felt that pro forma was unnecessarily detailed for this group of patients.	As a trauma stamp was already in use to aid in trauma patient management, this was modified to include a caries risk assessment (Fig. 4).

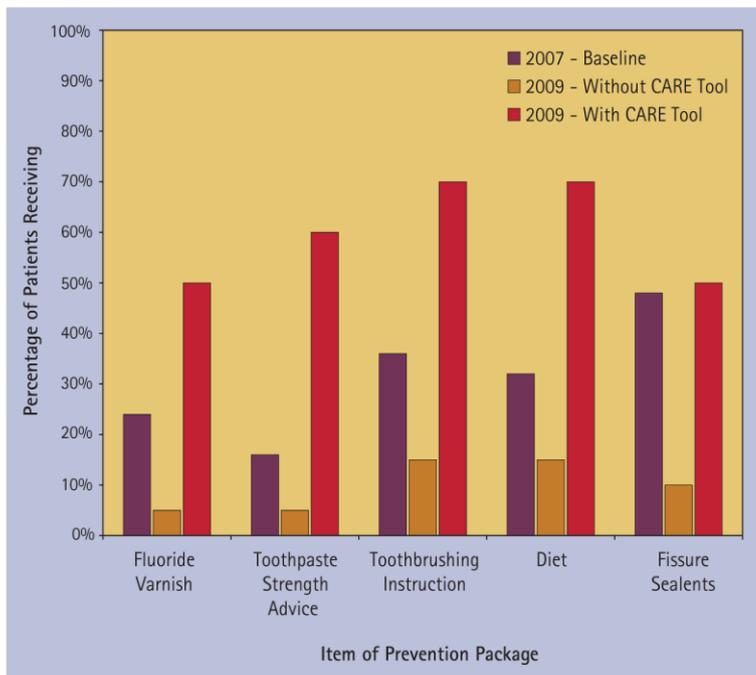


Fig. 6 Percentage of patients who received elements of preventive treatment in 2007 and 2009

(estimate for difference = 38%, p = 0.004) appear to have improved significantly.

DISCUSSION

This pilot project demonstrated this methodology was associated with delivering improvements in the documentation of

CRA and delivery of preventive care. The project's continuous nature allowed the identification of barriers to improvement and changes devised to address them, for example, the introduction of the PCPCS for casual patients who required their own CARE tool. This project encouraged

Preventive measure	2007 (n = 50)	2009 with CARE tool (n = 20)	Estimate for difference	95% CI for difference	p-value
Fluoride varnish	24% (12)	50% (10)	21%	47.4%, -5.4%	0.115
Toothpaste strength advice	16% (8)	60% (12)	44%	69.4%, 18.6%	0.001
Toothbrushing instruction	36% (18)	70% (14)	24%	50.8%, -2.8%	0.077
Diet advice	32% (16)	70% (14)	38%	63.3%, 12.7%	0.004
Fissure sealants	48% (24)	50% (10)	20%	29.5%, -25.5%	0.883

improvements beyond the areas originally envisaged; for example, the PCPCS also improved communication with the referring dentist. The project also motivated staff to improve the quality of health promotion literature within the department.

The sampling system was designed to cause minimal disruption to clinic working, while providing contemporaneous results. The sample size of 20 case notes every second week was judged as adequate to reflect the general patient patterns within the department. This method of data collection was highly visible, which in itself acted as a reminder to complete a CARE tool. However, some limitations were that: results were subject to selection bias by the investigator; notes from some clinics were not available to the investigators; and results had to be collected before case notes left the clinic, which may prejudice results against members of staff who may have later completed a CARE tool. However, to provide contemporaneous feedback to facilitate improvement, it was elected to accept these shortcomings.

The main change concepts introduced by this project revolved around development of new working processes in an endeavour to improve patient care, along with continuous monitoring and feedback as advocated by the PDSA model.¹¹ Some of the more notable changes are noted in Table 1 and Figure 5. Overall our changes revolved around regular monitoring, regular feedback and engaging with all members of the team. This meant the working group not only regularly measured the uptake of the CARE tools but also regularly took opportunities to both give and receive feedback from the staff within the

department. Feedback might be given formally at a departmental meeting or via an email, but equally constructive comments may arise during brief conversations during the working day. Overall the feedback received from staff was positive with regard to the improved patient care being provided. Staff did note that completing the CARE tools does generate some extra work but this was not felt to be excessive and worth the perceived benefit to patient care and working processes. It has since been decided to continue the project to build upon the success of the pilot, the aim being to continue to develop work flows which place appropriate dental caries prevention at the heart of the treatment received by every patient.

As this project progressed, the desirability of an outcome measure for the effects of improving preventive care was discussed. The obvious measure of this would be the incidence of new carious lesions. Unfortunately, as dental caries is a multifactorial and relatively slow developing disease, evaluation of incidence of new carious lesions as an outcome measure would be outside the scope of an improvement project with no additional funding. However, given the strength of the evidence supporting the effectiveness of the preventive interventions, we are confident that ensuring their effective application should have a net patient benefit in terms of reduction of future dental caries.¹²⁻¹⁵

This project demonstrates a successful model for improving delivery of preventive care for patients. By targeting CRA, the first key step in delivery of prevention, we have demonstrated improved delivery of a range of preventive interventions.

We did achieve our 80% target for CRA completion on five occasions by the end of the project. However, our aim for the future will be not only to achieve 95% plus CRA completion, but to achieve our target consistently, potentially a significant challenge of its own. While this project was hospital-based, the quality improvement principles involved could be translated into a system suitable for use in primary dental care.

Thank you to J. Thompson, and everyone within the paediatric and medical records departments at Glasgow Dental Hospital and School for their assistance with this project. Appreciation is extended to Mr William Peters, an Improvement Advisor with the IHI, for preparing the SPC charts in this analysis.

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5 Project Protocol

Introduction

Dental caries has a multi-factorial aetiology. It is also a preventable disease. The 2008 NDIP survey has shown that amongst primary one (P1) children dental caries is not evenly spread throughout the population, as 11% of P1 children had 50% of the obvious decay experience.¹

This means that prevention would be most effective at reducing disease levels by targeting those most at risk. Effective prevention needs to be holistic and targeted on all levels, from society as a whole, through communities and down to the level of the individual. The majority of dental practitioners will work on the level of the individual patient, and will have to assess that patient's risk factors, and tailor their prevention appropriately.

Current guidelines²⁻³ reflect this by stating that all children should be individually assessed for their caries risk status, and then based on this status an appropriate prevention package should be implemented.

Previous departmental audits showed poor documented compliance with these guidelines within the department of Paediatric Dentistry at Glasgow Dental Hospital & School. Since Glasgow and the West of Scotland in general, have the highest prevalence of dental caries in Scotland¹, this was an area which would benefit from a health care improvement approach. Implementing change to improving clinical care can be challenging and requires commitment to an on-going and evolving process.⁴

Within the wider health care community there is acceptance that the quality of care needs to be constantly improving. The Institute of Medicine set out the broad aims that health care should be safe, effective, patient-centred, timely, efficient and equitable⁵. These aims have been widely adopted, including by the NHS in the UK⁶. New models for delivering improvement in health care have been developed from statistical process control, a process originally developed in the 1920s to aid in quality control in manufacturing. It was not till the 1980s that the application of statistical process control methodologies began to be applied in medicine⁷. The Institute for Health Improvement (Harvard, Boston) was founded in 1991 to advocate the usage of these methodologies, which it calls the "Model for Improvement".

Currently there has yet to be a reported application of these new health improvement models in the field of dentistry. Within the department of paediatric dentistry at Glasgow Dental Hospital & School we have commenced using the Model for Improvement. This project will be a continuation and expansion of a pre-existing health improvement project within the department of paediatric dentistry. This pre-existing project began in August 2008 with the introduction of a revised Caries Risk and Prevention Plan pro forma (see appendix 1) and a run chart (see appendix 3) to monitor its uptake. Data for the run chart was collected by an examiner randomly choosing two case notes from any patient seen by any practitioner at every morning and afternoon for a week, and this was done on a fortnightly basis.

The run chart was displayed on the clinic, a fortnightly update email was sent to all staff, and results were presented and discussed at departmental clinical governance meetings. Feedback from this study led to the development of a wider toolset which now includes:

- The Caries Risk and Assessment pro forma (see appendix 1)
- The Comprehensive Patient Care Sheet (see appendix 2)
- Primary Care Provider Communication Pad (see appendix 4)
- Updated Trauma Stamp (see appendix 5)

This MSc project will aim to take these changes further by expanding on the previous work, under the title of the “CARE” project. This will involve setting new targets, both for the uptake of this CARE toolset and for delivery of preventive care, and supporting these targets with further changes as required.

Aims

1. For every patient attending the department of paediatric dentistry to be caries risk assessed and an appropriate prevention plan devised.
2. For patient attending the department of paediatric dentistry for comprehensive care, their preventive care will be delivered as planned.

Targets

To aid in achieving the above aims, initially the following targets will be monitored:

1. Continued monitoring of the use of CARE tools, and to exceed the current target of 80% of patients attending the department of paediatric dentistry to have a completed CARE tool. Therefore setting a new target of 95% of patients attending the department of paediatric dentistry will have a completed CARE tool by August 2010.
2. For patients attending on a one off or specialist advice/treatment, a target of 95% having their caries risk status communicated to their primary care provider will be met by August 2010.
3. For comprehensive care patients, a target of 95% will have their preventive care delivered according to the prevention plan
 - The prevention plans should contain the following items:
 - The appropriate time interval for radiographs to diagnose caries.
 - The appropriate strength of fluoride toothpaste for the patient to use.
 - The appropriate time interval between professional applications of high strength fluoride varnish.
 - If required, any additional fluoride supplements the patient should be taking.
 - If required, any advice regarding diet, covering both food and drinks.
 - If required, any detailed instruction regarding appropriate oral hygiene technique.
 - If required, any teeth which require the application of fissure sealants.

- If required, advice regarding the dental impacts of any medications the patient may be on.
4. Monitor the impact of the project: this will be accomplished by comparing the standard of preventive care in Glasgow Dental Hospital & School with other paediatric dental units in the UK.

Methods

To aid in implementing this new project, the investigator aims to gain knowledge and experience of new health improvement methods used in the wider health care community. This will include undertaking an appropriate literature search, secondments to appropriate units and completion of the open school training courses on the Institute for Health Improvement website⁷.

A new protocol for collecting data will be instituted which will work by:

- Every week 5 cases notes selected at random from all patients who attended that week.
- These cases notes will be reviewed for the following items:
 1. A correctly completed and up-to-date CARE tool is present in the notes.
 2. That the patient's caries risk status has been communicated to the primary care provider.
 3. If a comprehensive care patient, that their preventive care is being delivered as planned.

The results will be plotted on the following graphs:

- Control chart plotting the results of item 1 above
- Run charts plotting results of items 2 & 3 above

This expanded protocol will start in August 2009, and will be launched with a training event explaining the aims and methods of the project to all staff involved. A new training document (see appendix 6) detailing the use of all the CARE tools will be given to all staff at this event. This training document will also be used for the induction of all new staff to the department. At this meeting the investigator intends to recruit members for a project group to meet fortnightly and direct any further changes required to meet the intended aims of the project. Finally at this meeting a questionnaire will be distributed asking for feedback on individual experience of the project so far. This same questionnaire will be repeated every 3 months for the duration of the project.

To assess the impact of this project on preventive care standards, a survey of paediatric dental units in the UK will be distributed. This will involve sending an anonymous data collection sheet to each unit, and asking them to complete it for the preventive care received by the first 15 comprehensive care patients who have attended for a year or more starting on Monday 1st November 2010.

The data from this project will be displayed on both run charts and a control chart. As see in appendix 3, a run chart is a plot of results against time, with annotations showing the target for the results and any event which would influence the result. The run chart is a good, easy to understand, visual representation of the impact the improvement project is having on your target

result. A control chart is similar to a run chart in that it plots the results against time, but has 3 special lines also plotted on it. These are the median of the data, and upper and lower control limit. These control limits are calculated as 3 standard deviations from the median, and allow extra analysis of the results. Any variation between results which lies within these control limits is considered to be noise inherent to the system, i.e. "Common Cause Variation", and therefore insignificant. Any variation between results which is outside the control limits on the control chart is considered significant, and is identified as "Special Cause Variation" using this methodology. The probability of a data point randomly being outside the control limits, without some underlying "special cause variation", is about 1 in 370⁹. This means that there is the most to learn from investigating point which demonstrate special cause variation. We aim to investigate any result that shows special cause variation, so that any special factors can be identified and learnt from.

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(Accessed April 2008)

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March 2001

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6 Ethical Approval

Keightley Alexander (NHS Greater Glasgow & Clyde)

From: Una MacLeod <uml1j@clinmed.gla.ac.uk>
Sent: 28 May 2009 08:54
To: Keightley Alexander (NHS Greater Glasgow & Clyde)
Subject: RE: Project Status

Dear Dr Keightley
Yes, I agree this is audit
Kind regards
Una Macleod

Dr Una Macleod
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The University of Glasgow, charity number SC004401 -----Original Message-----
From: Keightley Alexander (NHS Greater Glasgow & Clyde) [<mailto:a.keightley@nhs.net>]
Sent: 27 May 2009 20:31
To: uml1j@clinmed.gla.ac.uk
Subject: Project Status

Dear Sir/Madam

I have attached a document detailing a summary of a project we intend to carry out within the department of Paediatric Dentistry at Glasgow Dental Hospital and School. We believe that it falls under the category of audit, but would be grateful if you could verify this for us.

I would also appreciate if you could indicate what timescale you are working to at present.

Yours sincerely,

Alexander J Keightley
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16 July 2009

FAO Caroline Campbell
Consultant in Paediatric Dentistry
Glasgow Dental Hospital & School
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Glasgow

Dear Carrie

**Full title of project: IMPROVING QUALITY OF CARIES PREVENTION – A
LONGITUDINAL AUDIT PROPOSAL**

Thank you for seeking my advice about the above project.

You provided the following documents for consideration:

Background proposal
Email – to AHT 16 July 2009

I enclose a copy of our leaflet, "Defining Research", which explains how we differentiate research from other activities. I have reviewed the above documentation and advise that the project is not considered to be research according to this guidance. Therefore it does not require ethical review by a NHS Research Ethics Committee. It is my opinion that this is an Audit of current practice.

You should check with the R & D Department for NHS GG & C as to what other review arrangements or sources of advice apply to projects of this type. Guidance may be available from the clinical governance office.

This letter should not be interpreted as giving a form of ethical approval or any endorsement of the project, but it may be provided to a journal or other body as evidence that ethical approval is not required under NHS research governance arrangements.

However, if you, your sponsor/funder or any NHS organisation feels that the project should be managed as research and/or that ethical review by a NHS REC is essential, please write setting out your reasons and we will be pleased to consider further.

Where NHS organisations have clarified that a project is not to be managed as research, the Research Governance Framework states that it should not be presented as research within the NHS.

Yours sincerely

Andrea H Torrie
Senior/Lead Administrator
West of Scotland REC Service

E-mail: andrea.torrie@ggc.scot.nhs.uk

Copy to: [R&D office, NHS GG & C](#)

Enclosure: *NRES leaflet – "Defining Research"*

7 IHI Open School Certificate



INSTITUTE FOR
HEALTHCARE
IMPROVEMENT

CERTIFICATE OF COMPLETION

BASIC LEVEL

THIS CERTIFICATE IS AWARDED TO

Alexander Keightley

IN RECOGNITION OF SUCCESSFUL COMPLETION OF

THE BASIC CURRICULUM OF THE

IHI OPEN SCHOOL FOR HEALTH PROFESSIONS



Maureen Bisognano

Maureen Bisognano
President and CEO
Institute for Healthcare Improvement

8 CARE Toolkit

Caries Risk Assessment and Prevention Plan

Patient Label	Clinician	
	Date of Assessment	
	Date for Re-assessment	

Caries Risk Assessment

Clinical Evidence	Dietary Habits	Social History	Fluoride Use	Plaque Control	Saliva	Medical History	Caries Risk
L H	L H	L H	L H	L H	L H	L H	L M H

Height Percentile Weight Percentile

Prevention Plan

Radiographs (Frequency)	Toothbrushing Instruction	Strength F Toothpaste (F ppm)	F Varnish (Frequency)	F Supplements (Dose)	Diet Advice (Food & Drink)	Fissure Sealants	Sugar Free Medicines

Clinician Date of Assessment

Caries Risk Assessment

Clinical Evidence	Dietary Habits	Social History	Fluoride Use	Plaque Control	Saliva	Medical History	Caries Risk
L H	L H	L H	L H	L H	L H	L H	L M H

Height Percentile Weight Percentile

Prevention Plan

Radiographs (Frequency)	Toothbrushing Instruction	Strength F Toothpaste (F ppm)	F Varnish (Frequency)	F Supplements (Dose)	Diet Advice (Food & Drink)	Fissure Sealants	Sugar Free Medicines

Date of Re-Assessment

Longitudinal Record of Prevention

Prevention Method	Date Discussed / Treatment Carried Out							
Radiographs								
Toothbrushing Instruction								
F ⁻ Toothpaste								
F ⁻ Varnish								
F ⁻ Supplements								
Diet Advice								
F/S								
Sugar Free Medicines								

Pilot project CARE Sheet (Front and Back)

Comprehensive Patient Care Sheet

Clinician
 (Consultant In Charge)
 Date of Assessment

Height m^h
Weight m^h

Clinical Evidence	Dietary Habits	Social History	Fluoride Use	Plaque Control	Saliva	Medical History	Caries Risk
L H	L H	L H	L H	L H	L H	L H	L M H

Radiographs (Frequency)	Toothbrushing Instruction	Strength F Toothpaste (F ppm)	F Varnish (Frequency)	Supplements (Dose)	Diet Advice (Food & Drink)	Resin Sealants	Sugar Free Medicines
<input style="width: 40px;" type="text"/>							

Radiographs Available Y N Date Taken Views

Diagnosis 1. 2. 3.

Treatment Plan

Item	Description	Completed Date	Initial	Date of Next Visit
1	Give Diet Diary, Apply Fluoride Varnish	<input style="width: 40px;" type="text"/>	<input style="width: 40px;" type="text"/>	<input style="width: 40px;" type="text"/>
2	Review Diet Diary, Give TPS Advice	<input style="width: 40px;" type="text"/>	<input style="width: 40px;" type="text"/>	<input style="width: 40px;" type="text"/>
3	<input style="width: 100px;" type="text"/>	<input style="width: 40px;" type="text"/>	<input style="width: 40px;" type="text"/>	<input style="width: 40px;" type="text"/>
4	<input style="width: 100px;" type="text"/>	<input style="width: 40px;" type="text"/>	<input style="width: 40px;" type="text"/>	<input style="width: 40px;" type="text"/>
5	<input style="width: 100px;" type="text"/>	<input style="width: 40px;" type="text"/>	<input style="width: 40px;" type="text"/>	<input style="width: 40px;" type="text"/>
6	<input style="width: 100px;" type="text"/>	<input style="width: 40px;" type="text"/>	<input style="width: 40px;" type="text"/>	<input style="width: 40px;" type="text"/>
7	<input style="width: 100px;" type="text"/>	<input style="width: 40px;" type="text"/>	<input style="width: 40px;" type="text"/>	<input style="width: 40px;" type="text"/>
8	<input style="width: 100px;" type="text"/>	<input style="width: 40px;" type="text"/>	<input style="width: 40px;" type="text"/>	<input style="width: 40px;" type="text"/>
9	<input style="width: 100px;" type="text"/>	<input style="width: 40px;" type="text"/>	<input style="width: 40px;" type="text"/>	<input style="width: 40px;" type="text"/>
10	<input style="width: 100px;" type="text"/>	<input style="width: 40px;" type="text"/>	<input style="width: 40px;" type="text"/>	<input style="width: 40px;" type="text"/>

On Treatment Plan Completion

<input style="width: 90%;" type="text"/>	<input style="width: 90%;" type="text"/>	<input style="width: 90%;" type="text"/>
--	--	--

Longitudinal Record of Prevention

Prevention Method	Date Discussed / Treatment Carried Out							
Radiographs	<input style="width: 40px;" type="text"/>							
Toothbrushing Instruction	<input style="width: 40px;" type="text"/>							
F Toothpaste	<input style="width: 40px;" type="text"/>							
F Varnish	<input style="width: 40px;" type="text"/>							
F Supplements	<input style="width: 40px;" type="text"/>							
Diet Advice	<input style="width: 40px;" type="text"/>							
F/S	<input style="width: 40px;" type="text"/>							
Sugar Free Medicines	<input style="width: 40px;" type="text"/>							

Initial CARE Sheet from August 2009 Launch (Front and Back)

Comprehensive Patient Care Sheet

Clinician
(Consultant In Charge)
 Date of Assessment

Height n^m

Weight n^m

Caries Risk Assessment							
Clinical Evidence	Dietary Habits	Social History	Fluoride Use	Plaque Control	Saliva	Medical History	Caries Risk
L H	L H	L H	L H	L H	L H	L H	L M H

Prevention Plan						
Radiographs (Frequency)	Toothbrushing Instruction	Strength F ⁻ Toothpaste (F ⁻ ppm)	F ⁻ Varnish (Frequency)	F ⁻ Supplements (Dose)	Diet Advice (Food & Drink)	Sugar Free Medicines

Diagnosis: 1. 2. 3.

Treatment Plan For treatment with:

Consultant Signature

Date

Discharge to GDP / CDS

Review on:

Discuss with:

Longitudinal Record of Prevention

Prevention Method	Date Discussed / Treatment Carried Out							
Radiographs								
Toothbrushing Instruction								
F ⁻ Toothpaste								
F ⁻ Varnish								
F ⁻ Supplements								
Diet Advice								
F/S								
Sugar Free Medicines								

CARE Sheet following October 2010 revisions

Glasgow Dental Hospital & School
378 Sauchiehall Street
GLASGOW G2 3ZJ

DEPARTMENT OF PAEDIATRIC DENTISTRY

☎ Direct Dial 0141 211 9670

GDP Information

Patient Information

Dear

The above patient was seen in the Department of Paediatric Dentistry at Glasgow Dental Hospital on the following date regarding: CARIES TRAUMA OTHER: _____

Examination revealed: CARIES: _____

Treatment will be as follows (Please circle):

1. Comprehensive Care under GA at RHSC	2. Management of trauma within GDHS
3. Extractions only under GA at RHSC	4. All treatment and care within GDHS Paediatric Clinic

(Unless noted in box 4 above, the responsibility for the patient's routine examinations, routine treatment and pain management remains with the primary care provider)

PREVENTION ADVICE

This patient's caries risk is currently: HIGH MEDIUM LOW (This risk should be regularly reviewed)

The following Prevention Plan is recommended to be carried out in the Primary Care setting as per current SIGN guidelines:

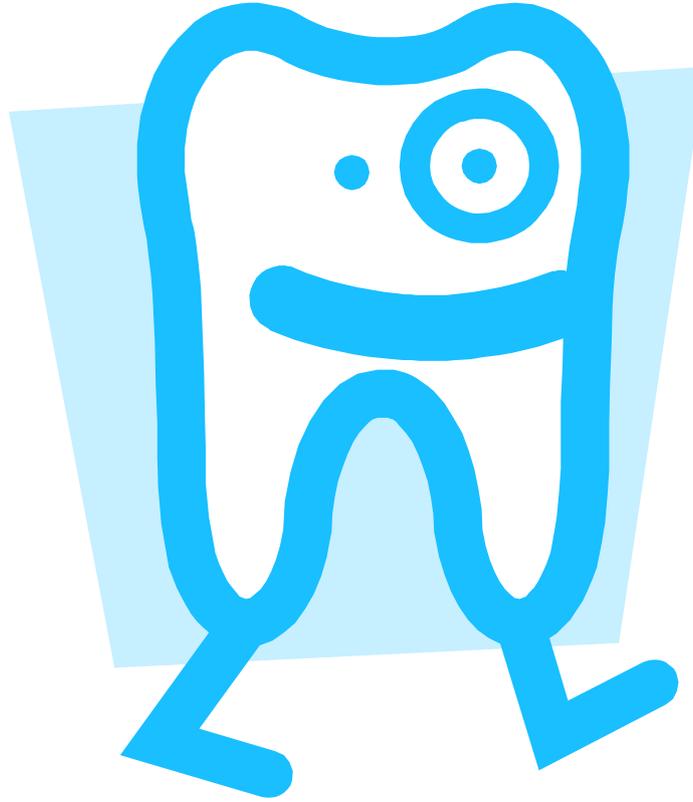
Prevention Plan	(Please circle as appropriate)			
RECALL PERIOD	4 monthly		6 monthly	
RADIOGRAPHIC PERIOD	6 months	12 months	18 months	24 months
FLUORIDE VARNISH (Duraphat)	4 monthly		6 monthly	
TOOTHPASTE STRENGTH	1,000 ppm F		1,500 ppm F	
TOOTHBRUSHING INSTRUCTION	YES		NO	
DIETARY COUNSELLING	YES		NO	
FISSURE SEALANTS TO BE APPLIED <i>(Notate teeth to be sealed)</i>	_____			

Thank you for your collaboration in improving this patient's oral health

(SIGN AND DATE)

Primary Care Provider Communication Sheet (PCPCS)

GLASGOW DENTAL HOSPITAL AND SCHOOL
DEPARTMENT OF PAEDIATRIC DENTISTRY



THE CARE PROJECT PROTOCOL

A patient's caries risk status is an amalgamation of the multitude of factors which influence the development of caries in that patient. Assessment of a patient's caries risk status requires evaluation of evidence based risk factors, along with using clinical judgement. This evaluation of caries risk status should then guide the delivery of a package of appropriate caries preventive care. This should ensure that every patient receives the benefit of preventive care appropriate to their needs, and that we ensure that our resources relating to prevention are used in the most effective manner.

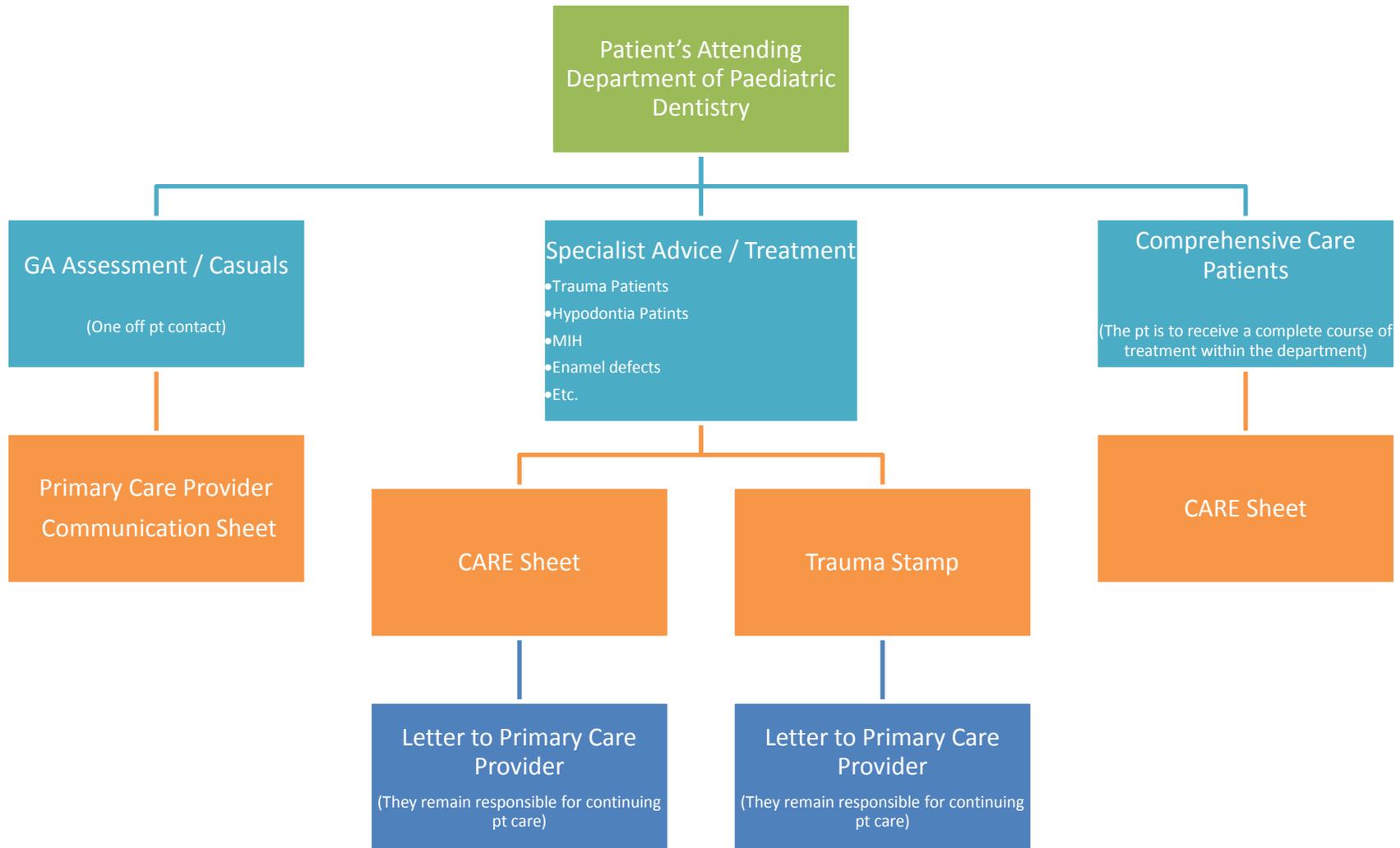
Within the department of paediatric dentistry we aim for every patient attending the department to:

- Individually assess their caries risk status
- Prescribe an appropriate caries prevention package
- Ensure that this caries prevention package is effectively delivered within the department or appropriately communicated to the primary care provider

Various tools are available on the clinic in order to aid in achieving these aims, these include:

1. Comprehensive Patient Care Sheet
2. Primary Care Provider Communication Pad
3. Trauma Stamp

This document describes the intended usage of these tools.



Comprehensive Patient Care Sheet (CARE sheet)

To be used for:

- Patient’s receiving specialist advice/treatment with preventive care to be completed by primary care or within the department
- Patient’s receiving on going comprehensive care within the department

This double sided sheet should be printed on yellow paper and is intended to be placed in the patient’s notes. It is intended to give an overview of the patient’s complete treatment needs including; caries risk assessment, prevention plan, diagnosis, treatment plan, and discharge procedure.

Fig 1. CARE Sheet Section 1

Comprehensive Patient Care Sheet

Patient Label		Clinician (Consultant In Charge)		
		Date of Assessment		
	Height		n th	
		Weight		n th

Caries Risk Assessment

Clinical Evidence	Dietary Habits	Social History	Fluoride Use	Plaque Control	Saliva	Medical History	Caries Risk
L H	L H	L H	L H	L H	L H	L H	L M H

Prevention Plan

Radlographs (Frequency)	Toothbrushing Instruction	Strength F Toothpaste (F ppm)	F Varnish (Frequency)	F Supplements (Dose)	Diet Advice (Food & Drink)	Fissure Sealants	Sugar Free Medicines

Section 1 should be completed with a patient label in the top left hand corner. The name of the clinician completing the CARE sheet along with the patient’s consultant should be named in the top right hand corner, followed by the date of assessment. A height and weight should be taken at the time of completing this sheet, and growth charts giving the percentile can be found next to the scales on the clinic. There is no date for re-assessment, as this will be done when all items on the treatment plan are completed. A caries risk assessment should then be carried out, and a prevention plan completed.

Some example prevention plans are:

Prevention Plan							
Radiographs (Frequency)	Toothbrushing Instruction	Strength F Toothpaste (F ppm)	F Varnish (Frequency)	F Supplements (Dose)	Diet Advice (Food & Drink)	Fissure Sealants	Sugar Free Medicines
18/12	✓	1000	6/12	✗	✗	✗	✗

Prevention Plan							
Radiographs (Frequency)	Toothbrushing Instruction	Strength F Toothpaste (F ppm)	F Varnish (Frequency)	F Supplements (Dose)	Diet Advice (Food & Drink)	Fissure Sealants	Sugar Free Medicines
6/12	✓	1450	4/12	.05% F- MW	✓	6 6 6 6	✓

Fig 2. CARE Sheet Section 2

Radiographs Available	Y	N	Date Taken		Views	
Diagnosis	1.		2.		3.	

Section 2 should give details of what radiographs were available at the time of completing this sheet. It also details the overall diagnosis for the patient, which should be along the lines of; caries 1° dentition, caries 2° dentition, anxiety, hypodontia, etc.

Fig 3. CARE Sheet Section 3

Treatment Plan		For treatment with:		
Item		Completed (Tick)	Initial	Date of Next Visit
1	Give Diet Diary, Apply Fluoride Varnish			
2	Review Diet Diary, Give TPS Advice			
3				
4				
5				
6				
7				
8				
9				
10				

On Treatment Plan Completion

Discharge to GDP / CDS	Review on:	Discuss with:
------------------------	------------	---------------

Section 3 details the treatment to be carried out. It should state which grade of staff this treatment plan is appropriate for. Each item of treatment is divided into two lines. The first line should be used for any interventional procedure to be carried out. The second line should be used for items of the prevention package to be delivered. There is already items relating to diet analysis and fluoride varnish printed on the sheet, this is because the majority of patients will require this.

Once an item on the treatment plan is completed it should be ticked off, initialled and the date for when the next item on the plan is to be done written on the sheet. This is to ensure progress is maintained in delivering the patient’s treatment.

If the patient is being referred back to primary care for prevention or any other item of treatment, this can be detailed on the treatment plan as a separate item by writing “To GDP for prevention” or “To GDP for restoration 36”, etc. When the letter is dictated this item can then be ticked off the treatment plan.

The bottom of section 3 details what should be done when the treatment plan is completed. This might simply involve appropriately discharging the patient back to their GDP. Or it may involve discussing the situation with a specified consultant, or arranging an appointment on a specified clinic.

Fig 4. The Longitudinal Record of Prevention

Longitudinal Record of Prevention								
Prevention Method	Date Discussed / Treatment Carried Out							
Radiographs								
Toothbrushing Instruction								
F ⁻ Toothpaste								
F ⁻ Varnish								
F ⁻ Supplements								
Diet Advice								
F/S								
Sugar Free Medicines								

The second page of the CARE sheet is a longitudinal record of prevention. The date of when an item on the prevention plan is completed is recorded on the longitudinal record of prevention. This can then be easily referred to at future visits to determine when items of preventive treatment were last done. If a letter is sent asking the primary care provider to complete all or some of the items on the prevention plan, please just note “To GDP” and the date of the letter in the longitudinal record of prevention.

Two examples of how to complete a CARE sheet are shown in Fig 5 and Fig 6.

**Fig 5. Example of a completed CARE Sheet
(All treatment within the department)**

Comprehensive Patient Care Sheet

Joe Bloggs V000000 15/04/99 5 Main Street Glasgow	<table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 40%;">Clinician (Consultant In Charge)</td> <td style="width: 60%;">A Dentist (A Consultant)</td> </tr> <tr> <td>Date of Assessment</td> <td>17/07/09</td> </tr> </table>	Clinician (Consultant In Charge)	A Dentist (A Consultant)	Date of Assessment	17/07/09
Clinician (Consultant In Charge)	A Dentist (A Consultant)				
Date of Assessment	17/07/09				

Height nth Weight nth

Caries Risk Assessment

Clinical Evidence	Dietary Habits	Social History	Fluoride Use	Plaque Control	Saliva	Medical History	Caries Risk
L (H)	L (H)	L (H)	L (H)	L (H)	(L) H	(L) H	L M (H)

Prevention Plan

Radiographs (Frequency)	Toothbrushing Instruction	Strength F ⁻ Toothpaste (F ⁻ ppm)	F ⁻ Varnish (Frequency)	F ⁻ Supplements (Dose)	Diet Advice (Food & Drink)	Fissure Sealants		Sugar Free Medicines
6/12	✓	1450	4/12	.05% F- MW	✓	54	45	✗
						54	45	

Radiographs Available Y N Date Taken Views

Diagnosis

Treatment Plan

For treatment with:

Item	Description	Completed (Tick)	Initial	Date of Next Visit
1	Acclimitisation Give Diet Diary, Apply Fluoride Varnish, Give F- MW			
2	Introduce Slow Speed - Prothy Review Diet Diary, Give TPS Advice, TBI			
3	Intro topical LA F/S's Right Hand Side			
4	Sealant Restoration 36 F/S's Left Hand Side			
5	Restore 11m 21m			
6	Study models, Clinical Photos			
7				
8				
9				
10				

On Treatment Plan Completion

Discharge to GDP / CDS	Review on: Hypodontia Clinic	Discuss with:
------------------------	------------------------------	---------------

**Fig 6. Example of a completed CARE Sheet
(Referred to Primary Care for Prevention)**

Comprehensive Patient Care Sheet

Joe Bloggs V000000 15/04/99 5 Main Street Glasgow	Clinician (Consultant In Charge) A Dentist (A Consultant)	Date of Assessment 17/07/09
Height 140 cm n th 50th Weight 31 kg n th 50th		

Caries Risk Assessment

Clinical Evidence	Dietary Habits	Social History	Fluoride Use	Plaque Control	Saliva	Medical History	Caries Risk
L (H)	L (H)	L (H)	L (H)	L (H)	(L) H	(L) H	L M (H)

Prevention Plan

Radiographs (Frequency)	Toothbrushing Instruction	Strength F ⁻ Toothpaste (F ⁻ ppm)	F ⁻ Varnish (Frequency)	F ⁻ Supplements (Dose)	Diet Advice (Food & Drink)	Fissure Sealants		Sugar Free Medicines
6/12	✓	1450	4/12	.05% F- MW	✓	54	45	✗
						54	45	

Radiographs Available Y N Date Taken **17/07/09** Views **PA 11, BWs**

Diagnosis **1. Avulsion 11** **2. Caries** **3.**

Treatment Plan For treatment with: **SHO**

Item	Completed (Tick)	Initial	Date of Next Visit
1 RCT 11			
Give Diet Diary, Apply Fluoride Varnish			
2 Review Diet Diary, Give TPS Advice			
3 Letter to GDP to restore 36 and to carry out prevention			
4			
5			
6			
7			
8			
9			
10			

On Treatment Plan Completion

Discharge to GDP / CDS	Review on: Trauma Clinic	Discuss with:
------------------------	--------------------------	---------------

The Primary Care Provider Communication Pad

To be used for:

- All patient’s attending for paed’s assessment
- All patient’s attending paediatric casualty bay for the first time

This triplicate pad fulfils two important functions. It firstly provides communication back to the patient’s primary care provider regarding the outcome of their attendance at the department. Secondly it provides a quick method to record the patient’s caries risk status and advise on the appropriate prevention plan. The pad is a carbon copy triplicate pad, this allows the first copy to be posted to the patient’s primary care provider, the second copy is given to the patient or parent at the appointment and the final copy is kept in the patient’s notes as a record.

Fig 7. The Primary Care Provider Communication Pad, Top Section

Glasgow Dental Hospital & School 378 Sauchiehall Street GLASGOW G2 3ZJ	
DEPARTMENT OF PAEDIATRIC DENTISTRY	☎ Direct Dial 0141 211 9670
GDP Information	Patient Information
Dear	
The above patient was seen in the Department of Paediatric Dentistry at Glasgow Dental Hospital on the following date regarding:	
<input type="checkbox"/> CARIES	<input type="checkbox"/> TRAUMA
<input type="checkbox"/> OTHER:	
Examination revealed:	CARIES:

The top section should be filled out with labels for the GDP details and patient’s details should be placed at the top of the sheet. The primary care provider’s name, the date of the patient’s attendance, and the patient’s reason for attendance is completed. Any caries found during examination can be charted on the grid, and other findings or trauma can be noted on the lines below.

The outcome of the appointment is then circled, these fall into four categories:

1. Comprehensive Care under GA at RHSC
2. Management of trauma within GDHS
3. Extractions only under GA at RHSC
4. All treatment and care within GDHS Paediatric Clinic

Fig 8. The Primary Care Provider Communication Pad, Outcomes

Treatment will be as follows (Please circle):	
1. Comprehensive Care under GA at RHSC	2. Management of trauma within GDHS
3. Extractions only under GA at RHSC	4. All treatment and care within GDHS Paediatric Clinic

Then under prevention advice the patient’s caries risk should be circled, and based on this an appropriate prevention plan recommended. Some examples can be seen below:

High caries risk patient

PREVENTION ADVICE		
This patient’s caries risk is currently: <input checked="" type="radio"/> HIGH <input type="radio"/> MEDIUM <input type="radio"/> LOW (This risk should be regularly reviewed)		
The following Prevention Plan is recommended to be carried out in the Primary Care setting as per current SIGN guidelines:		
Prevention Plan	(Please circle as appropriate)	
RECALL PERIOD	<input checked="" type="radio"/> 4 monthly	<input type="radio"/> 6 monthly
RADIOGRAPHIC PERIOD	<input type="radio"/> 6 months	<input checked="" type="radio"/> 12 months <input type="radio"/> 18 months <input type="radio"/> 24 months
FLUORIDE VARNISH (Duraphat)	<input checked="" type="radio"/> 4 monthly	<input type="radio"/> 6 monthly
TOOTHPASTE STRENGTH	<input type="radio"/> 1,000 ppm F	<input checked="" type="radio"/> 1,500 ppm F
TOOTHBRUSHING INSTRUCTION	<input checked="" type="radio"/> YES	<input type="radio"/> NO
DIETARY COUNSELLING	<input checked="" type="radio"/> YES	<input type="radio"/> NO
FISSURE SEALANTS TO BE APPLIED <i>(Notate teeth to be sealed)</i>	6	6
	6	6

Low caries risk patient

PREVENTION ADVICE		
This patient’s caries risk is currently: <input type="radio"/> HIGH <input type="radio"/> MEDIUM <input checked="" type="radio"/> LOW (This risk should be regularly reviewed)		
The following Prevention Plan is recommended to be carried out in the Primary Care setting as per current SIGN guidelines:		
Prevention Plan	(Please circle as appropriate)	
RECALL PERIOD	<input type="radio"/> 4 monthly	<input checked="" type="radio"/> 6 monthly
RADIOGRAPHIC PERIOD	<input type="radio"/> 6 months	<input type="radio"/> 12 months <input checked="" type="radio"/> 18 months <input type="radio"/> 24 months
FLUORIDE VARNISH (Duraphat)	<input type="radio"/> 4 monthly	<input checked="" type="radio"/> 6 monthly
TOOTHPASTE STRENGTH	<input checked="" type="radio"/> 1,000 ppm F	<input type="radio"/> 1,500 ppm F
TOOTHBRUSHING INSTRUCTION	<input type="radio"/> YES	<input checked="" type="radio"/> NO
DIETARY COUNSELLING	<input type="radio"/> YES	<input checked="" type="radio"/> NO
FISSURE SEALANTS TO BE APPLIED <i>(Notate teeth to be sealed)</i>		

The Trauma Stamp

To be used for:

- All trauma patient's

The trauma stamp is an important tool in the management of trauma patient's. The trauma stamps within the department all have caries risk as one of the items to be evaluated when completing the stamp, and should be done as standard. If patient is evaluated as being high caries and restorative care is to be undertaken within the department, a yellow CARE sheet should be completed. If the patient is evaluated as being high caries risk and there is no restorative care required or it is to be undertaken by GDP, a preventive plan should be prescribed by either letter or by using the Primary Care Provider Communication Pad.

Current clinical guidelines relating to caries risk assessment and prevention planning can be found at:

SIGN 83 - Prevention and management of dental decay in the pre-school child (November 2005, currently due for review)

<http://www.sign.ac.uk/pdf/sign83.pdf>

SIGN 47 - Preventing dental caries in children at high caries risk: Targeted prevention of dental caries in the permanent teeth of 6-16 year olds presenting for dental care (December 2000, reviewed 2005)

<http://www.sign.ac.uk/pdf/sign47.pdf>

American Dental Association Clinical Recommendations - Professionally applied topical fluoride: Evidence-based clinical recommendations (August 2006)

<http://ebd.ada.org/ClinicalRecommendations.aspx>

American Dental Association Clinical Recommendations - Evidence-Based Clinical Recommendations for the Use of Pit-and-Fissure Sealants (March 2008)

<http://ebd.ada.org/ClinicalRecommendations.aspx>

9 Power Calculation

Sample size calculation for Paediatric Audit project

Alex Keightley & Richard Welbury

16th March 2011

Andrea Sherriff

Scenario 1

Based on a minimum clinically important difference between the two groups (2007 & 2009) of 20%. Eg. Caries risk assessment in 2007=40% and 60% in 2009.

You would have 90% power to detect a minimum difference in percentages of 20% between the groups, with n=140 in each year.

You would have 80% power to detect a minimum difference in percentages of 20% between the groups, with n=107 in each year.

Scenario 2

Based on a minimum clinically important difference between the two groups (2007 & 2009) of 30%. Eg. Caries risk assessment in 2007= 30% and 60% in 2009.

You would have 90% power to detect a minimum difference in percentages of 30% between the groups, with n=63 in each year.

You would have 80% power to detect a minimum difference in percentages of 30% between the groups, with n=49 in each year.

NB These numbers are calculated for STATISTICAL significance-based on what you consider to be CLINICALLY significant.

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