Developing a Dental Electronic Patient Record for the Permanent Defence Forces

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A dissertation submitted to the University of Dublin
in partial fulfilment of the requirements for the degree of
Master of Science in Health Informatics

2009

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Summary

This thesis considers the factors influencing the development of an Electronic Patient Record (EPR) in the Dental Service of the Permanent Defence Forces. The format of forensic dental charting on paper records and in commercially available electronic records is considered. The information categories in commercially available EPRs are catalogued and deficits noted. The coding of these elements in an electronic record for the Dental Service can then be designed. Issues of IT infrastructure, data management and governance are also addressed so that policies may be developed in these areas.

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List of abbreviations

ADA	American Dental Association
AF	Army form
BDR	Baseline Dental Record
CDO	Chief Dental Officer
CIS	Communications and Information Systems
COS	Chief of Staff
DCOS(Ops)	Deputy Chief of Staff (Operations)
DCOS (Sp)	Deputy Chief of Staff (Support)
DF	Defence Forces
DFHQ	Defence Forces Headquarters
DFTC	Defence Forces Training Centre
DO	Dental Officer
E Bde	Eastern Brigade
ECDL	European Computer Driving Licence
EPR	Electronic patient record
ICD	International Classification of Diseases
IS	Information System
LA	Leabhar Airm (Army book)
MIF	Management Inventory Framework
NHS	National Health Service
PDF	Permanent Defence Forces
PMS	Personnel Management System
RDF	Reserve Defence Forces
S Bde	Southern Brigade
SNOMED	Systematized Nomenclature of Medicine
UK	United Kingdom
US	United States
W Bde	Western Brigade

1 Introduction

1.1 Context statement

The Defence Forces (DF) has an in-house Information System for managing Human Resources known as the Personnel Management System (PMS). Its original purpose was to computerize certain administrative functions recorded on paper to increase the efficiency of these processes and to enhance management control. It contains a dental module within a larger medical module. The dental module records certain clinical records with an emphasis on dental charting. It is proposed that the dental module should evolve into a complete Electronic Patient Record (EPR) suitable for Defence Forces purposes.

The purpose of this thesis is to identify factors that may affect the development of the dental module of the PMS. It examines the format and content of forensic dental charting in commercial EPRs, the dental module of the PMS and on paper charts because a complete forensic dental record of every soldier is captured. It examines the structure of commercial EPRs so that appropriate information categories can be proposed for the dental module of the PMS. The administration associated with the business of dentistry in the Defence Forces is also examined. The aim is to identify key data elements in the paper based system that should be coded into the dental module.

Other issues such as the IT infrastructure and the attitudes of Dental Service personnel, at operator and at management level, to issues such as data management and governance are discussed. They allow the definition of IT and training requirements and the formulation of governance policies.

Finally, this thesis collates the findings of this research into specific recommendations to the developers of the PMS and to the management of the Dental Service. Of equal importance, it identifies areas for future work to clarify or develop the findings of this thesis.

1.2 Background

The Defence Act, 1954, affords the Government the authority to "to raise, train, equip, arm, pay and maintain defence forces to be called and known as Óglaigh na hÉireann or (in English) the Defence Forces" (Defence Act, 1954). The Defence Forces is organized into a component of

full-time soldiers known as the Permanent Defence Forces (PDF) and a part-time reserve known as the Reserve Defence Forces (RDF). The former is composed of 10,434 personnel divided between the Army, the Naval Service and the Air Corps and the latter is composed of 8408 personnel supporting the Army and the Naval Service (Department of Defence, 2007).

The Defence Forces describes its mission as "to contribute to the security of the State by providing for the military defence of its territorial integrity and to fulfil all roles assigned by Government, through the deployment of well-motivated and effective Defence Forces" (Defence Forces, available at: http://www.military.ie/dfhq/overview/role/index.htm Accessed 31 May 2009). In practice, the roles which it trains for are:

- To defend the state against armed aggression – this is often described as contingency planning that is proportional to the low threat level that Ireland enjoys.
- Aid to the civil authorities, in particular, An Garda Siochana, who are broadly an unarmed force.
- Deployment on overseas missions subject to the so-called 'triple lock' of United Nations (UN), Government and Dail approval.
- Fishery protection in line with European Union (EU) commitments
- Other duties as may be assigned by Government from time to time including Ministerial Air Transport and an Air Ambulance service.

Considerable re-organization, downsizing and modernization occurred in the Defence Forces following a Government White Paper in 1998 (Department of Defence, 1998). There are now three Army Brigades (No 2 Eastern, No 1 Southern and No 4 Western); a Defence Forces Training Centre (DFTC) in the Curragh Camp, Co Kildare; a headquarters, Defence Forces Headquarters (DFHQ), in Dublin; an Air Corps based in Baldonnel; a Naval Service based in Haulbowline, Co. Cork and an enterprise logistics element, the Defence Forces Logistics Base (DFLB) located in the Curragh Camp, Co Kildare.

The Army Brigades are organized along conventional military lines as self-contained light mechanized forces. Each has Infantry battalions as well as Combat Support elements (Artillery, Cavalry, Communications & Information Systems and Engineer Corps) and Combat Service Support elements (Ordnance, Medical, Transport, and Military Police Corps). The overall effect of the re-organization following the Government White paper of 1998 was to significantly reduce the size of the support elements, including dental support.

1.3 The Defence Forces population group

Recruitment to the Defence Forces is either by enlisting as a Private soldier or by fulfilling the conditions necessary to be commissioned by the President as an Officer. The minimum recruitment age is 17 and mandatory retirement is based on rank, career courses completed and medical suitability to continue serving. Most Officers will have retired by their 56th birthday although Dental and Medical Officers and some other Technical Officers retire on or before their 65th birthday. Most of the other ranks retire after 21 years service – around the age of 40 – although some may serve until their 60th birthday. Approximately 10% of Defence Forces personnel are Commissioned Officers and act as the managers of the organization. Dental Officers and other specialist professions are recruited after graduation directly into the relevant Corps.

Soldiers are experts in the use of force and this, if unchecked, poses a threat to the State. Consequently, significant control is exerted over personnel at group and at individual level. Control is exerted through a hierarchical rank structure that is at odds with civil society which tends to have a flatter organization socially and in the work place. The legal basis for control rests in the Defence Acts and in their associated Statutory Instruments, the Defence Forces Regulations (DFRs). Military law regulates conduct to a greater level than that found in civilian life and soldiers are accountable to military law at all times, even when off-duty.

In addition to the formal structures there are also societal norms in the Defence Forces that define the nature of life within the organization. Discipline, loyalty and physical fitness are emphasised. Personnel serve overseas where along with the physical discomforts soldiers have

to bear the separation from family and friends in environments that can be dangerous. In total, 85 Irish soldiers have been killed while serving overseas on peacekeeping operations. (Defence Forces, available at: http://www.military.ie/overseas/index.htm Accessed 18 August 2009).

Military life is physically demanding and a specific medical system has evolved to deal with the particular working environment. Before recruitment, personnel are pre-screened and excluded if they have a range of mild and more serious diseases e.g. colour blindness, asthma, cystic fibrosis etc. While serving, personnel have to complete an annual physical fitness test and an annual medical examination. Personnel who cannot complete their fitness test or who fail their annual medical may be medically examined to assess their suitability to continue serving and may be medically retired. Soldiers are also randomly tested for legal or illegal drug misuse; positive test results are followed by administrative discharge.

The military culture and the particular medical system have an effect on the composition of the Defence Forces population. The Defence Forces population is characterized by being 95% male; has a particular age demographic with a concentration in the 25 to 45 year old group; is physically fitter than the general population and uses less legal and illegal drugs than the general population. As a consequence, there is a low level of morbidity from the conditions that affect the general population and less lost work days from these medical conditions in the Defence Forces than in civilian workplaces.

1.4 The Defence Forces Dental Service

1.4.1 Requirement for a Dental Service

It has been stated that the level of morbidity from medical conditions is lower in the Defence Forces than in the general population as a result of the exclusionary medical system. By contrast, dental fitness is not a significant exclusionary factor in recruitment to the Defence Forces, a situation mirrored in Armies throughout the world. The result is that the primary cause of lost work days in most Armies is dental sepsis.

Dental problems in deployed troops are known to adversely impact on the ability of operational commanders to maintain an effective force in the field. Recent reviews of dental casualty rates of UK personnel in Iraq (Richardson 2005) and US Army personnel in Kosovo (Chaffin and Moss 2008) indicate a casualty rate of around 150 visits per 1000 troops per year. Casualty rates in troops that are not made dentally fit before deployment have been recorded as being up to 5 times higher (Mahoney and Coombs 2000). Deutsch recorded that dental problems accounted for 6.9-9.3% of all medical evacuations from US nuclear submarines between 1991 and 1999 (Deutsch 2008). Little evidence is available from Defence Forces deployments. One preliminary study indicates that dental casualty rates may be as high as 400 visits per 1000 troops per year (Crotty, 2008).

It is in this context that a dental service is provided to Defence Forces personnel. The service maximises the number of fit troops that a unit commander has at his disposal by treating personnel suffering from dental disease and returning them to duty. Other roles of the Dental Service will be expanded in section 1.4.2 below. The service is free at the point of care and the level of service is defined by the Chief Dental Officer on behalf of the sovereign consumer, the Chief of Staff.

Dental service delivery is managed in the Defence Forces by Dental Officers. The establishment and strength of Dental Officers in the Dental Service is outlined in Table 1 below.

Table 1: The establishment and strength of Dental Officers in the Permanent Defence Forces

	Establishment	Strength
Chief Dental Officer	1	1
Brigade Dental Officer	3	3
Dental Officer	5	1

There was a reduction in clinician numbers following the re-organization of the 1990s and there are continuing difficulties recruiting and retaining Dental Officers. Hayden analysed the Dental Service for the periods 1960-69, 1970-79 and 1980-89. In these time periods the mean dentist/patient ratio was 1300, 1793 and 1821 patients per dentist, respectively (Hayden 1995). Currently there are 5 Dental Officers servicing a population of 10,434 personnel – that is, a dentist/ patient ratio of 2086 patients per dentist. The increased dentist/ patient ratio affects the ability of the service to carry out all its roles. The roles of the service are examined in the following section.

1.4.2 Roles of the service

Although a Defence Forces Dental Service (DFDS) has been in operation since the beginning of the State (Hayden 1995) there had not, until recently, been a definition of its role. In 2005 the Internal Audit Group, Department of Defence, carried out an investigation into the economic merit of the Dental Service. While finding that the Service provided value-for-money, they demanded a business plan to which the Dental Service could be held accountable. In response, the Chief Dental Officer wrote a business plan that contained measureable goals, performance indicators and role definition. Key roles are outlined below.

1.4.2.1 Dental forensic charting

Teeth and associated restorations are remarkably robust and will survive long periods of immersion in water and soil. As a result, dental forensic charting may be used in the identification of otherwise unidentifiable human remains. Dental forensic charting is of low cost in comparison to other techniques such as DNA recovery. In addition, dental records are often readily available and dental characteristics are usually unique to an individual (Adams 2003).

Service life is hazardous in comparison to civilian occupations. As well as the risks associated with operational deployment, soldiers handle firearms and explosives and operate machinery in settings more dangerous than most that hold similar civilian occupations. Soldiers have been killed in off-road driving accidents and in explosions while at work; aircrew have died in air accidents during search and rescue missions and sailors have been lost at sea. It is for this

reason that there is a Defence Forces Regulation that all soldiers have a forensic dental charting on joining the Defence Forces.

In addition, it is estimated from battle statistics that 30% of fatalities recovered from the battlefield are identified solely by dental remains (of the others, 30% are identified by pocket contents, 30% by dog-tags and 10% by other means) (Hayden 2005). With the proliferation of direct energy weapons on the battlefield and other explosive ordnance and the fact that personnel are being carried in armoured vehicles that combust when destroyed, the proportion of casualties on the battlefield that need to be identified by dental charting may be rising. For these reasons personnel serving overseas must have a forensic dental charting by a Dental Officer prior to deployment.

Accordingly, accurate forensic dental charting is a key aspect of military dental practice. However, no standards for dental forensic charting exist. This research will include an examination of the conventions used in charting by dental personnel as well as the charting in commercial EPRs and in forensic programs. The results will be used to define the coding of the forensic charting in the dental module of the PMS.

1.4.2.2 Field deployment

The Dental Service maintains the capacity to deploy a field dental service to provide dental treatment in locations where no other dental service is available. Dental teams have been deployed to the Congo; to the Lebanon; to Honduras and to Chad. This is a function that cannot be civilianized as deployment is to troubled countries where there would be practical and ethical issues associated with deploying a civilian service. The Defence Forces has purchased a mobile dental surgery to fulfil these obligations. Deployment of dental teams has been of a limited nature due to the on-going recruitment difficulties.

Units that serve overseas have a link to the Defence Forces intranet by satellite and dental teams may access the dental module of the PMS where the infrastructure is provided. The future development of the dental module of the PMS must be mindful of the operational deployment of the service and the need for information exchange with other Armed Forces. For instance, troops of many nationalities were treated by Dental Officers stationed in Chad. The

Dutch, who were co-located with the Irish, had a requirement that the treatment provided should be entered into the Dutch EPR.

1.4.2.3 Provision of dentistry

In the military, personnel are required for duty at home or overseas. Personnel are classified by Dental and Medical Officers as fit for duty using fitness classification schemes. A dental fitness classification in use in the Partnership for Peace organization has been adopted by the Dental Service. The dental classes are:

- Dental Class 1: no dental treatment needed
- Dental Class 2: dental disease unlikely to cause an emergency appointment within 12 months
- Dental Class 3: dental disease that is likely to cause an emergency appointment within 12 months
- Dental Class 4: Not classified within the last 12 months

Personnel in Dental Classes 1 and 2 are suitable for most operational deployments. Personnel in Dental Class 4 can be re-classified by examination. Personnel in Dental Class 3 can be reclassified by carrying out treatments to render them to the appropriate level of dental fitness (Dental Class 1 or 2). In an ideal dental health system the number of personnel in Dental Class 1 would be maximized while minimizing the number of treatments provided as well as the associated expenditure. An Information System is needed that is capable of tracking these metrics.

Thus dental treatments are provided to maximize the number of fit troops. Dental treatments are provided by Dental Officers stationed at military medical facilities throughout the State. Paper based records are in use and the clinical information tends to be fragmented especially in the case of Officers whose service career is characterized by movement between military stations. It is proposed that the dental module of the PMS will be expanded to become an EPR.

The research work carried out in this thesis includes an examination of the categories of clinical information in commercial EPRs and the results will be used to make recommendations as to the future development of the dental module of the PMS.

The high dentist/patient ratio means that it is not possible for the Dental Service to carry out all the work necessary to make personnel fit for duty. As a consequence, dentistry is purchased through a tender system from civilian dentists. A range of items has been selected that the whole population may receive through this system without prior approval. For instance, examinations, simple fillings and routine extractions are items of treatment form part of this group.

There are also procedures that high-risk groups need that are costly and must be assessed by a Dental Officer on a case-by-case basis. Financial sanction for these procedures is authorized by the Finance Branch of the Dept of Defence. The treatment for high-risk groups is provided by Dental Officers and by specialists on referral. Molar endodontics, dentures and crowns are all subject to prior approval. Demand for these treatments does not always indicate need as a certain amount of supplier-induced demand exists. It is essential that some means of tracking this kind of data is incorporated into the PMS so that the cost-utility can be assessed.

1.5 Administration in the Dental Service

The Defence Forces has an administration system that has been in operation since the beginning of the State. Every soldier in the Defence Forces has a unique identification number known to them, the Army number, by which they may be identified. The Army number is also used as a unique reference number when interacting with external agencies.

Army forms and Army books (Leabhar Airm) are used to record and transfer information in the Defence Forces. In the Dental Service other forms, such as consent forms and referral forms, have come into use. These documents form a paper-based Information System. The key data elements in these forms will be examined and the data flow will be modelled so that essential data can be coded into the dental module of the PMS.

Certain elements of the paper-based Information System are subject to regulation or use by external agencies and computerization may not be possible. Prescriptions for drugs and for dental appliances are subject to national and EU legislation that requires the retention of a paper copy. Other forms are used as vouchers to external organizations for services, such as for the statutory entitlement to exemption from hospital charges. However, it may be desirable to examine these types of forms to see whether their integration into clinical workflow should result in their incorporation into the dental module of the PMS.

The Defence Forces has an Information System composed of two elements, the Personnel Management System (PMS) and the Management Inventory Framework (MIF). The PMS is used to track the location and disposition of personnel; the latter is used to track stock and process billing. The PMS has a dental charting and administration package that is undergoing development. The content and structure of the dental module of the PMS will be examined in relation to its proposed function as an EPR.

The Military Administration School runs a plethora of courses to train personnel as operators and managers of the PMS and MIF. Courses in word processing, database design, the ECDL etc are also available. No policy exists at present that defines the courses required to work in a particular appointment in the Dental Service. This research will examine the types of courses that personnel have completed. Deficits in training can be identified with a view to creating a list of desirable courses for each appointment. The additional issue of IT availability and governance will also be addressed.

1.6 Research questions

The general question asked during this research is: What factors must be considered when designing an Information System used to support the Defence Forces Dental Service?

In order to answer this question the following sub-questions are asked: How is dental forensic charting coded? What data elements do commercial dental Information Systems use? What data elements are used to support the business of dentistry within the Defence Forces and who uses them? What IT, data management and governance issues need to be addressed?

1.7 Reader's guide

The first chapter has introduced the domain of the Defence Forces Dental Service. Chapter 2 reviews the relevant literature. Chapter 3 describes the research methods employed. Chapter 4 describes the results and evaluates them in light of the existing knowledge. Chapter 5 gives a synopsis of the results, recommendations and outlines further work necessary in the field. Appendices and references are located after chapter 5.

1.8 Conclusion

The Defence Forces Dental Service has a business plan that has measureable goals at service and unit level. Measurement of these goals is dependent on an adequate flow of information from unit level to the Chief Dental Officer. Computerization offers the benefits of enterprise-wide access to data, accuracy and completeness that is of particular importance in a service with restricted clinician numbers.

Computerization of processes must be considered in an environment of government fiscal difficulties, public sector recruitment freezes and the demand for value for money. Some elements may lend themselves to workflow changes and/ or computerization that will provide benefits without significant cost outlay. Broadly, these are the items that may be created by in-house dental and IT personnel. Computerization of other elements might require civilian software purchase; these have significant cost outlays especially in a geographically dispersed enterprise.

2 Literature review

2.1 Range of dental informatics literature

Dental informatics is a relatively new discipline regarded as having a comparatively sparse associated literature (Schleyer 2003a). Schleyer et al carried out an initial analysis of the literature in PubMed using high level search terms (computers AND research AND dentistry). The 10,477 returned papers published in the years 1975 to 2003 were sorted for relevance to dental informatics. Of this set 620 were published relating to dental informatics and a further 511 were published relating to IT in dental practice (Schleyer 2003b). We can conclude that in the domain of dental informatics the combination of high-level PubMed search terms shows high sensitivity and low specificity to the domain, which creates difficulty in searching for appropriate research papers. An additional difficulty is the low publication in the field (estimated currently at approximately 50 papers/ year).

Schleyer el al also estimated that dental informatics papers appeared in 176 separate journals between 1975 and 2003. No specific dental informatics journal exists at this time. A particular difficulty is the publication of articles in local journals such as the Journal of the Californian Dental Association and the Journal of the Indianan Dental association. These journals are not readily accessible.

Schleyer also found that 1672 individual authors had published dental informatics papers and of these 97% published three or fewer dental informatics papers. Given that most papers were published by authors publishing relatively few papers on the topic he concluded that the authors did not have a career in informatics. Mitchell has described papers written about the impact of computers on primary medical care as “a descriptive feast but an evaluative famine” and the same appears to be the case in the dental informatics domain as many of the papers appear to be observational rather than critical or analytical (Mitchell and Sullivan 2001). It is clear that there is a paucity of relevant critical research papers in the field.

Another area of concern that Schleyer reported is the relatively high proportion (72%) of papers that relate to imaging and image processing (Schleyer 2003b). By 2003, little had been published relating to dental Information Systems and specifically the coding of clinical systems. These restrictions on the information available mean that it is difficult to access relevant and current papers relating to the domain.

While it might be felt that publications relating to medical applications might form an appropriate alternative literature source, the specialist nature of dental work and dental Information Systems means that they are of relevance only in relation to the broader general principles that apply to all medical applications, such as, for instance the issue of privacy as it relates to medicine (Umar 2002).

2.2 Use of Dental Electronic Patient Records

2.2.1 Computer use in dental practice

Dental offices in the United States have "become increasingly computerized in the past 20 years" with an increase in use from 11% in 1984 to 85% in 2000 (Schleyer, Thyvalikakath et al. 2006). Similarly high rates of computer use are found in Canada – approximately 90% of Canadian dentists in 2006 were estimated to hold a PC in their office (Flores-Mir, Palmer et al. 2006a).

The most recent paper published on the subject in relation to Australian dentists' computer use was in 1991 and recorded that 37% of dental practices had a PC in their office (Hou and Barnard 1993).

In the UK in 1997 59% of practices had computers (Dental Practice Board, 1997) while a regional survey in the Thames Valley in 2003 noted that 77% of dentists had a computer "or were planning to do so" (John, Thomas et al. 2003). Recent research indicates that 100% of UK dentists now have computers in their offices (Wagner, Ireland et al. 2008). Feeney has reported in the Journal of the Irish Dental Association that "fewer than 20% of dental practices in Ireland are computerized" but no supporting reference is available (Feeney 2007).

This data relates to the presence of a PC in the dental office but does not distinguish between PCs used at reception for administrative functions and PCs used in the clinic to access Electronic Patient Records (EPRs). Flores-Mir conducted a survey of computer use by Canadian dentists which reported that 92% used computers for practice administration but made no note of use in the clinical area (Flores-Mir, Palmer et al. 2006a). Reports from the US indicate that computers are still mainly used for administrative purposes such as billing while clinical data tends to be recorded on paper. Thus while 85% of US practices have a PC, only 25% have PCs within the clinic environment and about 2% are paperless (Schleyer, Spallek et al. 2007).

Atkinson noted that US dental Information Systems generally lack scalability and are designed for multi-surgery clinics (Atkinson, Zeller et al. 2002). Since 75% of US clinics are single man clinics the logical consequence is that group practices have been found more likely to adopt an Information System (Schleyer, Thyvalikakath et al. 2006). No data relating to clinic size is recorded in Ireland but large group surgeries are uncommon. This may explain the reported low uptake of Information Systems in Ireland.

The low uptake of computers within the clinical environment has led to the "persistence of paper" and to significant overlap between the paper and computerized record (Schleyer, Spallek et al. 2007). However, the concurrent use of both paper and computerized records is known to cause inconsistencies between the two records and should be avoided where possible (Mikkelsen and Aasly 2001).

The literature in relation to Ireland is particularly scant. No reproducible information is available in relation to the use of dental Information Systems or their form or functions.

2.2.2 Paper and electronic records

Paper records have been in use in dental practices to record clinical findings for centuries although systematic record keeping has only evolved within the last decades (Schleyer, Thyvalikakath et al. 2007b). Similar dental paper records are also in use in general practice, in specialist practices and in dental hospitals. Paper records are inherently flexible and very little

needs to be coded onto a paper record as practitioners can simply write into blank text fields. The disadvantage is that this information cannot be readily collated to assess health outcomes without laborious analysis (Atkinson, Zeller et al. 2002). Paper records can also be easily lost or misfiled, creating gaps in the health record (Delrose and Steinberg 2000). By contrast, EPRs collect data in a manner that allows for more rigorous information analysis. However, deep domain knowledge and significant coding is required which often leads to a certain loss of flexibility in data collection (Schleyer, Thyvalikakath et al. 2006).

Paper records are easy and intuitive to use and can often be used without training. They are also inherently reliable but suffer from vulnerability to damage to from fire, flood or other disasters. Since they are not usually copied this represents permanent loss of the clinical record. EPRs require significant training to use, with attendant costs (Atkinson, Zeller et al. 2002) and usability is a common problem (Thyvalikakath, Schleyer et al. 2007). EPRs have the problems associated with reliability of hardware although this has prompted sophisticated offsite backup and disaster management strategies that may provide greater protection for clinical data (Huang 2004).

Paper records are cheap to buy and use whereas EPRs are expensive to buy; have annual maintenance costs; have associated business re-engineering and training costs and may cause further unforseen costs if integration issues arise (Shelley, Johnson et al. 2007). However, in paper records poor legibility, lost elements of the record and confusion caused by “variations in data recording methods” can lead to medical errors and litigation (Delrose and Steinberg 2000). EPRs have the capacity to reduce these problems by creating legible and more complete records and by using decision support. The cost savings attributable to decision support should be factored into the total cost of an EPR.

Where co-ordinated care is required paper records are seen as a barrier to the delivery of care as they must be copied or moved and this may lead to duplication or fragmentation of the record. EPRs can allow remote and multiple accesses to the same record which makes co-ordinated care easier to manage and reduces duplication in the record. However, the ease with which EPRs can be accessed has led to security concerns for the confidentiality of electronic

records. The confidentiality of paper records is often harder to breach as they must be physically accessed.

The physical existence of paper records also makes them portable which means that they require no infrastructure to be used at the point of care although they usually require considerable storage space. They are also easily integrated into care workflow but this may aid duplication of records where the original is not immediately to hand. EPRs require significant supporting infrastructure and since this is often bulky it is not always at the point of care. Data entry may be time consuming or require more attention than using paper records (Schleyer, Spallek et al. 2007). As a consequence, EPRs often interfere with clinical workflow (Schleyer, Thyvalikakath et al. 2006).

The advantages and disadvantages of paper and electronic records have been outlined above. In the following sections the arguments as they pertain to the particulars of dental practice will be investigated.

2.2.3 Rationale for computerization of dental practice

2.2.3.1 Increased efficiency

The rise in use of computers in dental offices tracked by the literature mirrors the general rise in computer use by society over the last 20 years. In the US, computers emerged in the 1960s with accounts receivable functions (Delrose and Steinberg 2000). The emergence of insurance schemes in the US and universal entitlements within the NHS in the UK created administration loads that benefited from computerization (Heid, Chasteen et al. 2002). Numerous papers have been published relating to increased efficiencies in the billing process (Stapley 2008), (McKenzie 2006), (Piccinini and Stephenson 2006).

Electronic submission of payment claims is possible in the UK and the US and this has also provided an incentive for the computerization of administration functions. Electronic transmission of claims is not possible in Ireland and may also explain the low uptake of computers in Irish dental practices. Practice management software has emerged that automates certain aspects of the clerking duties but still necessitates the printing and posting of

thousands of paper forms. The benefits of computerizing these processes have not been examined.

Clinical Information Systems can also improve efficiencies in attendance by providing electronic appointment books, recall lists and other management functions. Improved efficiency in scheduling was specified by dentists in the US during a recent survey of attitudes to computerization (Schleyer, Thyvalikakath et al. 2006).

2.2.3.2 Support for digital imaging

Dental practice differs from medical practice in the use of imaging technology because the dentist orders, usually captures and interprets the image (Nair, Pettigrew et al. 2008). Digital imaging offers the advantages of removing the costs associated with film processing; is faster to process than film; may use less ionizing radiation than film and allows images to be manipulated easily (Christensen 2004). It is not surprising, therefore, that digital imaging is reported as a reason for computerization in dental practice. Digital radiography is reported to be present in 11 to 30% of dental practices (van der Stelt 2008) in Norway, The Netherlands and the US.

Dental film x-rays are at a very high resolution (25 line pairs/mm) and the gold standard is to view these using a light box under correct viewing conditions (Nair, Pettigrew et al. 2008). Reproducing these conditions in a digital environment can be challenging. Vendors make claims about the resolution of their digital x-rays that will be difficult for the dentist to validate (Farman and Farman 2005). Monitors and monitor displays must be appropriate for displaying these images (MacDonald-Jankowski and Orpe 2007). In the context of the Defence Forces, the resolution required for forensic purposes may be lower than that required for treatment planning and this may be a factor in decision making.

The advantage of x-ray films is that they do not degrade over time and can be consulted many years later. However, images are frequently lost from patient files due to their small size (Christensen 2004). Centralized archiving of files should avoid such loss if the archiving process is robust. Archiving may involve lossless or lossy file compression with the latter having the advantage of needing less storage capacity but with the disadvantage of permanent

degradation of image quality. While some reports have indicated that loss of image quality is not a factor unless the image is reduced to less than 4% of the original (Eraso, Analoui et al. 2002), others have reported that the impact of lossy compression on diagnostic quality is hard to quantify (Fidler, Likar et al. 2006). Lossless compression is to be preferred until these issues have been resolved.

At enterprise level, neither dental PACS nor dental RIS exist. Nair has reported several difficulties encountered by dental schools using adapted medical PACS including: lack of protocols for the ordered presentation of dental images (so-called hanging protocols); lack of reconstruction schemes specific to dentistry; lack of post-processing filters and an inability to communicate with dental Information Systems (Nair, Pettigrew et al. 2008).

Of particular concern is the issue of file formats. Dental imaging commonly uses a proprietary file format and such images cannot be read by another IS. In some cases, different generations of the same system are incompatible (Farman 2005a). To solve these problems and to promote inter-operability, the National Electronic Manufactures Association (NEMA) and the American College of Radiology (ACR) in the US formulated standards known as DICOM standards (Digital Imaging and Communication in Medicine) for the format of images. Working Group 22 (WG 22) has issued Supplement 92 in relation to dental images including radiographs, video and photographic images. The American Dental Association has adopted the DICOM standard and has a scientific sub-committee that issues specifications to vendors to support interoperability (Farman 2005b).

No similar standards have been formally adopted in the UK or Ireland although DICOM has become the *de facto* international standard. However, Magni et al also reported in 2007 that many vendors had not yet adopted the DICOM standard (Magni, de Oliveira Albuquerque et al. 2007). It has also been reported that clinical Information Systems are often unable to handle the DICOM file format (Nair, Pettigrew et al. 2008). The position in the Irish market is unclear as no research on this matter has been published.

2.2.3.3 Data management

Data management was most frequently mentioned by US general dental practitioners as a reason for computerization (Schleyer, Thyvalikakath et al. 2006). The problems associated with paper records such as lost files, misfiling of records, legibility and the duplication of data may be avoided in a computerized record (Delrose and Steinberg 2000). There may also be easier document storage and access as well as access to clinical information that may be used to improve patient care (Atkinson, Zeller et al. 2002).

However, electronic records are subject to viruses, worms, data corruption etc so consideration must be given to virus protection, firewalls and data backup. Emmott has made the point that paper records and on-site backups of electronic data are equally vulnerable to fire, flood or theft (Emmott 2004). Off-site backups are more likely to avoid permanent loss of clinical data. Backup should be secure and reliable to protect patient confidentiality and to allow access to records should clinicians or patients seek them (McNamara 2008).

The issue of legacy data needs to be considered as the practice begins to use a clinical Information System. A management plan to archive paper records in such a way that they can be easily retrieved when needed must be developed (Stephenson 2008). Some practices transfer paper records into the new Information System but this involves considerable time and effort (Shelley, Johnson et al. 2007). It is also important to note that electronic records do not always have all the functions that will allow transition to a paperless office so consideration must be given to the on-going storage and management of those items (Lavine 2007). Duplication of paper and computerized records frequently occurs as dentists retain paper records until they are confident of the robustness of the Information System (Schleyer, Thyvalikakath et al. 2006).

Tele-dentistry (Atkinson, Zeller et al. 2002), data sharing within a dental school for audit purposes (Shelley, Johnson et al. 2007) and transfer of records to colleagues, specialists and medical practitioners (Heid, Chasteen et al. 2002) were identified as reasons for the computerization of records of dental hospitals. However, it should be borne in mind that no standards for dental records in paper or electronic form exist. Magni noted that 85% of all US records are paper based and that only 15 to 17% are interoperable (Magni, de Oliveira

Albuquerque et al. 2007). The implication is that there is limited advantage in being able to transmit computerized patient records as they may not be readable by another Information System. Adoption of relevant standards such as HL7 and DICOM are possible solutions. Some means of converting symbolic representations of teeth into text may also have to be considered if such data is to be exported to other systems.

2.2.3.4 Quality Assurance

Papers published by groups working in dental hospitals specified quality assurance (QA) as an area of interest following adoption of computer based systems (Atkinson, Zeller et al. 2002), (Shelley, Johnson et al. 2007). However, when Shelley published a paper relating to use of an Electronic Patient Record in a dental school to assess a dental care outcome his search of the literature found no record of any similar published study (Shelley, Johnson et al. 2007). It would appear that the use of dental Information Systems for QA purposes is still in its infancy.

By contrast, there is no mention of QA as a reason for computerization in a paper interviewing general dental practitioners in the US (Schleyer, Thyvalikakath et al. 2006). In Ireland, external agencies such as the RPII (Radiation Protection Institute Ireland) and HIQA (Health Information and Quality Authority) have begun to audit dental practice so it is likely that the QA functions of dental Information Systems will rise in relative importance.

2.2.3.5 Decision support

Umar has pointed out that decision making in dentistry is particularly difficult because of the recurrent nature of dental diseases, because multiple sites are affected and because of the changing risks that occur over time (Umar 2002). Conventional decision trees are unsuitable as they often incorporate simplistic assumptions that cannot return appropriate results. Clinical decision support can offer solutions to these problems, if a large enough database can be trained. A number of application exist including: a radiology system, ORAD (available at: http://www.orad.org); a caries simulation model (Downer and Moles 1998) and forensic identification tools, CAPMI and WinID. These are not in common use in dental practice.

2.2.4 Barriers to computerization of dental practice

2.2.4.1 Cost

It has been reported that up to 74% of IT projects do not return expected benefits (Shpilberg 2007). Peppard has commented that 20% of Chief Information Officers believe that IT investments fail to deliver value for money and another 25% were only "mildly convinced" that value had been returned (Peppard 2007). IT projects are also costly to implement: IT projects are reported to consume 2 to 10% of annual revenue and 50% of capital investment (Marchand 2008).

Flores-Mir has reported that 63% of Canadian dentists found cost a barrier to the implementation of an Information System (Flores-Mir, Palmer et al. 2006b). In the US 13% of dentists reported cost as a barrier to implementation and a further 11% reported it as a disadvantage following implementation (Schleyer, Spallek et al. 2007).

Schleyer has reported that clinical Information Systems provide an unpredictable return on investment as usability, technological obsolescence and staff training are difficult to quantify (Schleyer 2004). No systematic review of the economic benefit of clinical Information Systems is available. Papers tend to address the ease with which patient billing can be analysed and do not consider these factors (Stapley 2008), (McKenzie 2006), (Piccinini and Stephenson 2006).

The replacement of hardware can be relatively easily factored into annual expenditure (Walsh 2008). The effect of changing care patterns on the survival of a clinical Information System is more difficult to quantify. Paper records are flexible; clinical Information Systems must be equally adaptable during their life cycle if they are to remain useful (Heid, Chasteen et al. 2002). Obsolescence is a particular concern in the field of digital imaging where proprietary file formats are commonly used. As Farman has pointed out (Farman 2005a) hardware will inevitably be replaced and patient data is the valuable asset; to preserve the value of this asset, interoperability with other systems is essential.

The true economic cost of implementing an enterprise-wide clinical IS has also been found to be hard to evaluate. It has been reported that "little is known about how to implement electronic patient records in a complex dental school environment" (Walji, Taylor et al. 2009). It seems likely that difficulties with implementation will be associated with an

increasing cost burden. Shelley has reported that dental schools considered the high initial cost and ongoing maintenance costs as barriers to implementation (Shelley, Johnson et al. 2007). In one case researchers came to the conclusion that implementation could only be considered a success when the fees students charged patients were considered as a revenue source (Langabeer, Walji et al. 2008). On the basis of the literature, it may be concluded that implementation of an Information System is a high risk process with attendant cost implications.

2.2.4.2 Lack of standards

International standards are not well implemented in the domain of dental Information Systems. The ADA has published a series of standards in relation to clinical Information Systems (Available at: http://www.ada.org/prof/resources/standards/informatics_reports.asp#1004, Accessed 26 Mar 2009). These include standards for the structure of electronic health records, accounting performance, security requirements and data backup. However, because these standards do not dictate the content of the electronic health record, interoperability is still a difficulty (Harrell, Stanford et al. 2005). In addition, these standards are not always adhered to by vendors in the US further limiting interoperability (Magni, de Oliveira Albuquerque et al. 2007). It is likely that the introduction of health information portability legislation in the US will increase compliance with these standards (Tekavec 2008a). Similar standards have not been adopted in the Ireland, the UK or the EU.

Paper records are flexible and can be easily adapted to changing work patterns, specialities or operators. No standard for a dental paper or computer based record has been developed. Electronic records have been found to hold fewer data fields than are possible in paper records and this puts constraints on the ability of dentists to store clinical information (Schleyer, Spallek et al. 2007). Furthermore, there are no national or international standards in dental forensic charting (Chomdej, Pankaow et al. 2006). Variations between regions and specialities occur. Commercial packages develop proprietary symbols and classifications that affect the compatibility of data exchanged between applications (Umar 2002).

Health level 7 (HL7) is a standard that regulates the exchange of health information (typically from hospitals) in text format. There has been poor uptake of the HL7 standard in dentistry (Magni, de Oliveira Albuquerque et al. 2007). There are no messaging standards for tooth designation or surface or for periodontal charting (Schleyer 2004) and these are essential parts of a dental record. The absence of these standards impedes the electronic transmission of dental health care information from dental practices and from dental hospitals.

The issue of standards in relation to imaging has been discussed. The DICOM standard has not been fully implemented and this is limiting interoperability. Moreover, clinical Information Systems are available that cannot handle the DICOM file format (Nair, Pettigrew et al. 2008).

Diagnostic codes have emerged that may be used in dental Information Systems. Leake has described them as "computer readable descriptors of patient conditions" (Leake 2002). The WHO has published ICD-DA, the International Classification of Diseases in Dentistry and Stomatology. The diseases have been found to lack logical organization and are scattered throughout medical conditions with no differentiation between primary and adult teeth (Leake 2002). The ADA has collaborated with the College of American pathologists to produce another classification, SNODENT, as a subset of SNOMED (a more extensive medical terminology). SNOMED has been found to have a higher coverage of dental terminologies than either SNODENT or ICD-DA (Torres-Urquidy and Schleyer 2006). Formal adoption of any of these terminologies has not happened in Ireland.

Codes for treatment services have also emerged as the administration of billing has become computerized. They allow tracking of prescriber profiles, survival of restorations and other useful management information. Treatment codes may be linked to diagnostic codes to provide information about health outcomes. The ADA publishes a list of treatment codes (Available at: http://www.ada.org/prof/resources/topics/cdt/ Accessed 26 March 2009) that have become the US national standard following adoption by the US department of Health and Human Services (Pai and Zimmerman 2002). National standards for treatment codes do not exist in Ireland. The schemes run by the Departments of Health, Defence and Social Welfare use

different procedure codes. Coding of commercial Information Systems for is carried out by vendors.

A plethora of devices are found in the dental surgery including: CAD-CAM machines; intra-oral and extra-oral cameras; digital radiography and specialized sensors such as the Florida probe. These capture information that must be transferred to the clinical Information System (Levato 2004). However, because different companies are providing the hardware and software packages and no agreed standards exist to aid data transfer, integration between hardware and software has been reported to be almost non-existent in dental practices in the US and when integration happens it often leads to fragmented information (Schleyer, Thyvalikakath et al. 2006). Software bridges are commonly used as solutions but involve multiple interfaces that affect workflow and upgrading systems can cause peripheral systems to fail (Schleyer 2004).

Integration of devices is reported to improve efficiency and clinical outcomes for patients (Schleyer 2005). Most suppliers of dental units do not include software in the chair design but this is necessary if it is to hold computers and associated devices. Lack of integration leads to clutter in the surgery, extra cabling and routing boxes etc. (Schleyer 2004). The solution to these problems is the adoption of relevant standards.

In Ireland, in summary, there are no standards officially adopted or implemented. Dentists have to rely on the assurances of vendors in relation to interoperability. Future purchases of computer driven devices may test these assurances. Customers may become locked to vendors to ensure interoperability. Patients cannot be assured that their data can be given to them electronically, where requested, unless the dentist they attend subsequently has the same operating system. Clearly, a national strategy in this matter is necessary.

2.2.4.3 Workflow and usability

The primary driver of computerization has been the automation of administration functions. The computerization of clinical functions has followed but the conversion rate to paperless offices has been slow with less than 2% of US offices reported as completely paperless

(Schleyer, Spallek et al. 2007) and only 25% of US dentists use computers in the clinical environment (Schleyer, Thyvalikakath et al. 2006). Factors such as the lack of paper and electronic chart standardization; the socio-economic mix of dental practices and associated billing mechanisms; the varying technological mix of dental offices and the varying professional occupations found in dental offices affect the decision to computerize. Documenting typical workflow is necessary to maximize the benefits of computerization (Spence, Valenza et al. 2007).

Dental practices typically do not carry out workflow analysis before computerization. Research strongly indicates that the use of computers adversely affects workflow. Irwin et al discovered that 60% of the breakdowns in workflow in the surgery were associated with interactions with computers (Irwin, Torres-Urquidy et al. 2009). They also found that work with computers proceeds more slowly, needs more steps to completion and is more complicated than using a paper record. The conclusion is that dental practices adapt to accommodate computers rather than computers fitting into clinical workflow and improving work processes.

Cross-infection control was also noted to impede interaction with computers in the clinical area (Schleyer, Thyvalikakath et al. 2007a). Table 2 below indicates the proportion of data entered by surgery personnel (Schleyer, Thyvalikakath et al. 2006).

Table 2: percentage data entry by occupation

Dentist	23%
Hygienist	28%
Dental nurse	33%
Admin	16%

Dentists and hygienists capture the clinical data by direct interaction with patients. They also enter over half the data directly and will have to remove gloves, wash hands to do so and then re-glove to continue the patient encounter. Voice activated technology has been seen as a possible solution to cross-infection control concerns. Command driven and dictation systems are available; the advantage of the former is that the use of menus maintains privacy

(Drevenstedt, McDonald et al. 2005). The technology has not been standardized (Umar 2002) although such applications are common in radiology. Difficulties may arise with the use of masks and noisy surgery environments although recognition rates of 90% in trained databases are possible (Drevenstedt, McDonald et al. 2005). Schleyer has reported that 13% of US offices are using voice-activated technology but that a further 16% had tried the technology and subsequently stopped using it (Schleyer, Thyvalikakath et al. 2006).

Usability and complexity were described as the two greatest barriers to using computers at the chairside (Thyvalikakath, Monaco et al. 2008). Approximately 50% noted concerns with usability, functionality or charting and described steep learning curves when using the system for the first time (Schleyer, Thyvalikakath et al. 2006). They also described clinical Information Systems as "requiring more intensive navigation than paper records" and "more short term memorization" than paper records (Schleyer, Thyvalikakath et al. 2007a). Workflow analysis and user-centred design are required to overcome these problems.

2.2.4.4 Privacy and security

Paper records are fragmented so sensitive information is not easily accessed. By contrast, electronic records may be more easily accessed and are specifically managed so as to be retained for very long periods of time. This exposes patients to the risk of breaches in their confidentiality decades later. It may particularly be an issue in relation to compelled disclosure by insurance companies or employers. There is some evidence that patients may lie to their physician about their health in order to avoid such disclosures (Rothstein and Talbott 2006).

The Office of the Data Protection Commissioner has been established in Ireland to regulate the retention of personal data by organizations, including health care providers. Health care providers are now compelled by law to register with the Data Protection Commissioner and to comply with instructions as issued by his office. These instructions include having "adequate access controls, firewalls and virus protection" and having "retention policies for the various categories of data" (Available at: http://www.dataprotection.ie Accessed 26 June 2009). Controls such as time sensitive lock outs, automatic terminal lock outs, user access controls, passwords and password changing policies should be in place to help secure data (Tekavec

2008b). Reports have indicated that commercial systems often have lax security policies (Atkinson, Zeller et al. 2002). No current relevant publication in relation to such policies in dental practice is available.

Recent changes in the speed and availability of wireless technology pose new security risks for dental offices. Wireless security protocols must be adhered to so as to avoid compromising patient data, including billing information (Mupparapu and Arora 2004). The Internet is now being used to backup data remotely (McNamara 2008) as well as providing a source of relevant dental information. Internet access has been noted as a security concern by Canadian dentists (Flores-Mir, Palmer et al. 2006b). Appropriate security and policing is essential.

2.3 Content of Dental Electronic Patient Records

In general medical practice, records lend themselves to computerization as the data captured is alphanumeric in character e.g. progress notes, forms, laboratory notes, referral letters etc. Dental records contain alphanumeric data as free text or structured data in documents such as progress notes and referral letters that may also readily be computerized. However, dental records also usually contain dental charting, soft tissue charting, digital imaging (usually x-rays at very high resolution) and 3D models. These elements have proved to be more difficult to computerize. The elements typically found in a dental record and the difficulties associated with computerizing them will be examined in the following sections.

2.3.1 Progress notes

Progress notes are the main repository of knowledge in paper records. The inherent flexibility of paper records means that the same paper chart can be used by general dentists as well as by periodontists, hygienists, oral surgeons or other specialists. As stated in section 2.2.2 above, the disadvantage is that this information cannot be used for healthcare analysis without laborious examination of records.

A well designed EPR has appropriate coding that collects data so that healthcare analysis is possible. However, considerable domain knowledge is necessary to code an EPR appropriately. In addition, the primary motivation in practice for adopting an Information System is to improve administration and the coding of the EPR element is a secondary consideration. The consequence is that uncoded data is recorded in EPRs in progress notes. The information stored in progress notes has similar disadvantages to that stored in paper records. Therefore, careful consideration must be given in the Defence Forces as to the types of data that should be coded into the dental module of the PMS.

A consequence of the difficulties associated with the coding of dental records is that computerized practices generally use Information Systems to organize practice administration, such as appointments and billing, while progress notes are often on paper (Schleyer, Spallek et al. 2007). The flexibility of paper records and the fact that commercial systems cannot accommodate the types of information that dentists want to record also leads to duplication where records are recorded both on paper and the Information System (Schleyer, Thyvalikakath et al. 2006). Dental history, examination results, x-ray interpretation, QA and coding for diagnoses were elements duplicated in US dental clinics (Schleyer, Thyvalikakath et al. 2006).

An examination of the content of US paper and electronic records indicates that there is good agreement between paper records on the categories of information that should be coded but very little agreement between EPRs (Schleyer, Spallek et al. 2007). Few of the data fields found in paper records are found in EPRs and the title of fields in commercial EPRs often does not correspond to those in paper records (Schleyer, Spallek et al. 2007). Standardization of these elements is required.

2.3.2 Dental charting

An intra-oral examination involves screening soft tissues for oral cancer; recording the teeth and restorations present; examining the external and internal parts of teeth; examining the associated periodontium and diagnosing dental disease and conditions (e.g. fracture, wear). The 3-dimensional structures of the oral cavity must be recorded on paper or on a computer for display. In either case, a transformation to a 2-dimensional representation is effected. Dr

Walter Allport is reported as having developed the first 2D schematic dental chart to record findings in 1858 (Allport 1858); similar charts are in use today. The chart used by the DF Dental Service is displayed in Figure 1 below.

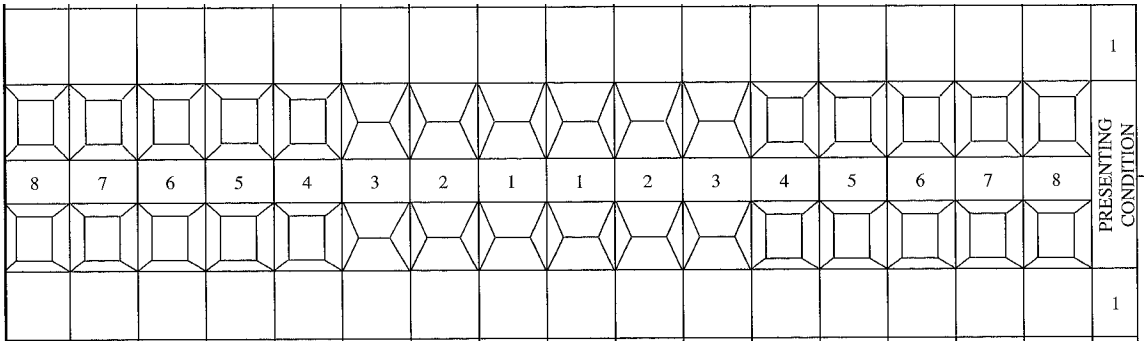


Figure 1: Defence Forces Dental Service forensic chart

The advantages of the schematic view are that an overview is quickly possible; symbols can be used to represent features or pathology and certain spatial relationships can be recorded. The disadvantages include the fact that the 2D representation only shows one projection; that internal structures are not easily recorded and that pathology is not always easy to record accurately (Schleyer, Thyvalikakath et al. 2007b).

2.3.2.1 Tooth notation

The first principle in relation to hard tissue charting is the identification of a specific tooth. Over 30 notations are in use worldwide (Rotzscher 1992). Many countries have dentists that use more than one notation system. This causes confusion and may lead to the provision of incorrect treatments; this is particularly common in extraction referral centres where incidences of the incorrect tooth being extracted are well documented (Pogrel 2003). The common tooth numbering systems are outlined below. A comparison of these numbering formats for the upper jaw is shown in Figure 2 below.

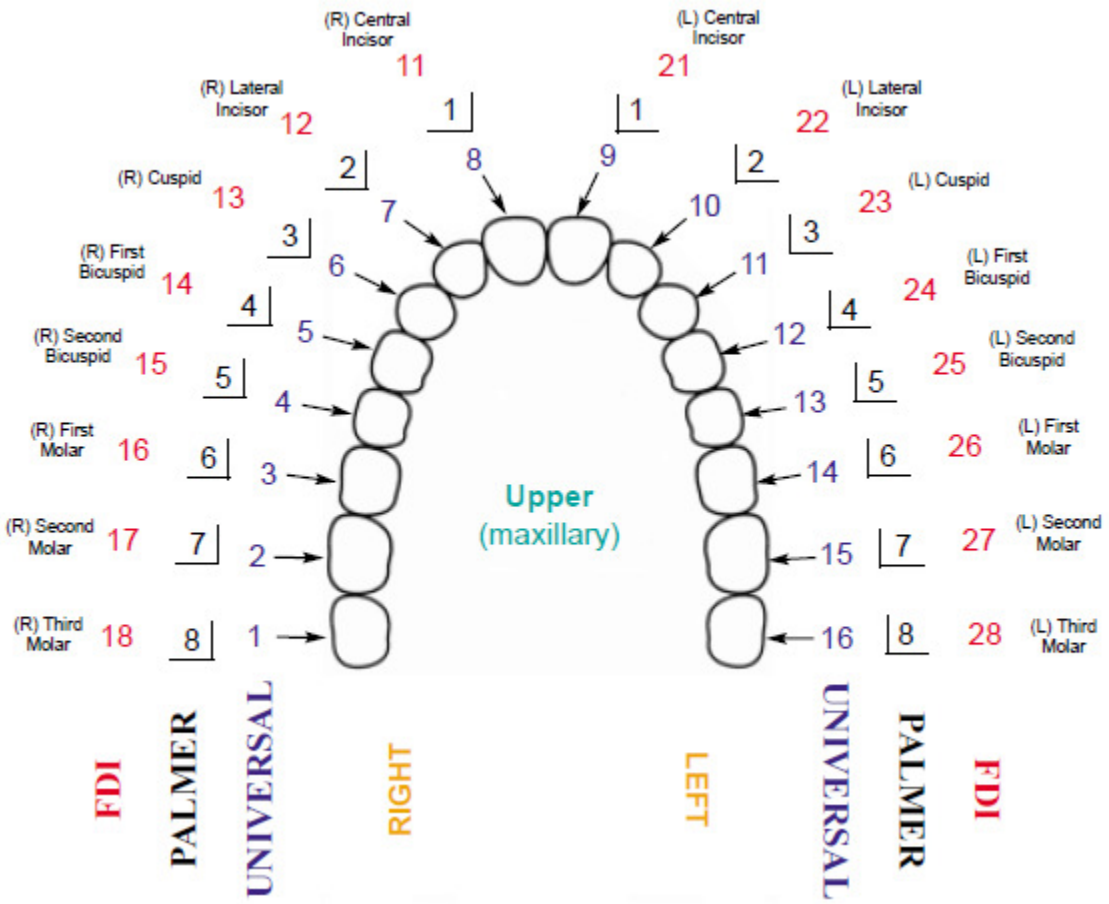


Figure 2: A comparison of the three common tooth numbering systems in the upper jaw

2.3.2.1.1 Zsigmondy

The Zsigmondy system - also known as Palmer notation - is in common use in the British Isles (Turp and Alt 1995) but is also used by some specialities in the US (Pogrel 2003). It is a convenient shorthand for paper records (Ferguson 2005). Examples of Zsigmondy charting are shown in Figure 3 below (Adapted from: Preston, M. Available at: http://en.wikipedia.org/wiki/File:E0303.png Accessed 31 May 2009).

Figure 3: lower left 1, upper left 6, lower right 8 and upper right 8 in Zsigmondy notation

A significant feature is that similar teeth have the same number. For instance, all first molars are 6s. However, this has occasionally caused problems in referral centres where the incorrect tooth has been treated because the Zsigmondy symbol was reversed in error (Chang, Lee et al. 2004). This system does not lend itself easily to use in computers as the symbols are not part of the Uni-Code data sets although specialized fonts can be imported (Ferguson 2005). When using word processing software it is common practice to convert the Zsigmondy symbol into plain English shorthand e.g. UL6 for the upper left first molar tooth. The other systems outlined below are preferable as they assign a specific number to each tooth.

2.3.2.1.2 ADA format

The ADA adopted a tooth numbering system in 1968 because of the confusion caused by lack of a national standard (Dofka 1996). The ADA format numbers adult teeth from 1 to 32 starting at the most distal molar tooth on the upper right hand side and moving in a clockwise direction, as shown in Figure 4 below (Available at: **http://healthhabits.files.wordpress.com/2009/02/teeth-numbering-chart. jpg** Accessed 27 June 2009**).**

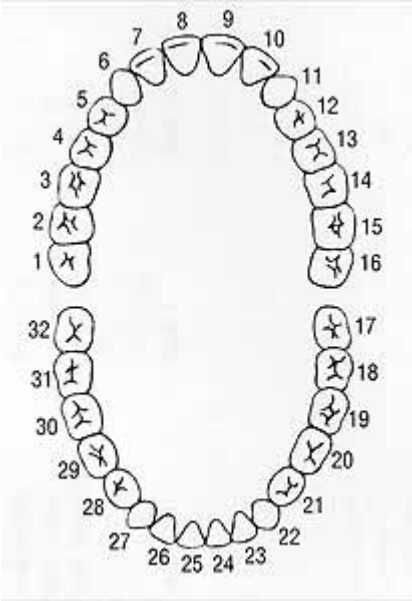


Figure 4: ADA tooth numbering format.

While the system at least confers a standard, there are two problems: firstly, it is not easily adaptable to include supernumerary teeth; secondly, it does not have “visual and cognitive sense” as the anatomical basis for tooth identification does not correspond to the numbering system (Peck and Peck 1993). For instance, first molars are teeth 3, 14, 19 and 30. As a result, there have been calls in the US to abandon this standard and adopt the FDI standard (Sare 1997).

2.3.2.1.3 FDI format

The Fédération Dentaire Internationale (FDI) adopted a tooth identification format in 1971 that has since become an international standard (ISO-3950). In this system quadrants of the mouth are assigned a number (1 to 4 in adult teeth) in a clockwise direction starting in the upper right quadrant. Teeth in each quadrant are numbered from 1 to 8 starting at the central incisor. Tooth identification is possible by using a two-digit format for each tooth: the first digit identifies the quadrant and the second digit identifies the tooth, as shown in Figure 5, below (Available at: http://users.forthnet.gr/ath/abyss/dep1151_1.htm Accessed 27 June 2009).

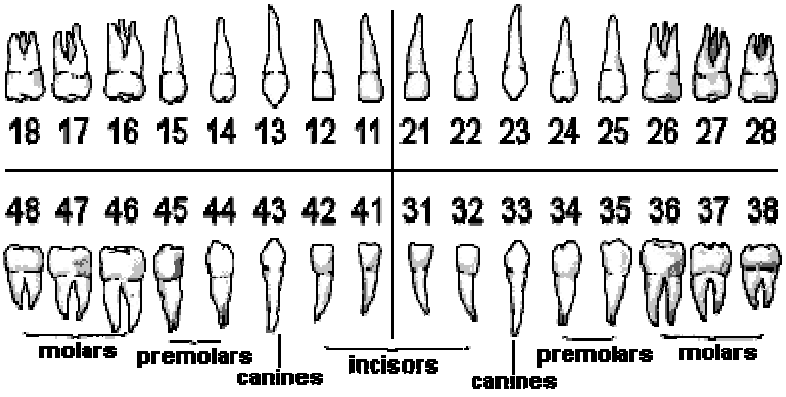


Figure 5: FDI tooth notation

This notation allows precise and simple identification of an individual tooth and its numerical format means that it is easily used in computer programs. It also has cognitive sense as the anatomical form of teeth corresponds with a specific number. For example, all wisdom teeth

are 8s (teeth 18, 28, 38 and 48) and all first premolars are 4s (teeth 14, 24, 34 and 44). In this regard it is more alike the Zsigmondy system than the ADA format.

2.3.2.2 Forensic charting

Dental forensic charting involves the comparison of *ante mortem* and *post mortem* dental records. It is a very successful means of identification as teeth and restorations survive immersion in water and soil almost indefinitely and will often be useful in victims of fires (Pretty and Sweet 2001). Forensic charting involves collecting a record from the deceased which includes teeth present or absent, restorations present, anatomical anomalies and radiographic evidence for comparison with *ante mortem* records, where necessary. However, no international standards exist for forensic charting although the recording of filled surfaces tends to follow the anatomical pattern. Symbols for restorations vary between region and region. Nonetheless, forensic charting has proved time and again to be capable of reliably identifying the deceased. 80% of the non-Thais drowned in the tsunami in South-east Asia in 2004 were identified by dental remains (Schuller-Gotzburg and Suchanek 2007). By contrast, although 18% of the missing Thais had a dental chart, only 7.4% of these charts could be used and only 2% of the missing Thais were subsequently identified by dental remains (Petju, Suteerayongprasert et al. 2007). In this case we can note that dental forensic charting by Thai dentists was inadequate for dental forensic identification.

The basis for identification relies on matching of characteristics. Lorton et al had noted that four or more identifiable characteristics allow identification and that error rates of 30% would still allow identification where five or more identifiable characteristics were present (Lorton and Langley 1986). He also noted that increasing the complexity of charting showed no increase in the power of selection. Caries had been excluded as a matching characteristic following determinations that caries identification is too subjective (Friedman, Novins et al. 1996).

The scientific basis for matching was explored by Adams (Adams 2003). He examined records of 9730 civilians and 19422 soldiers. The datasets were analysed in so-called detailed and generic formats: in the former teeth present and all surfaces filled were recorded whereas

in the latter teeth present and teeth filled were recorded. Adams discovered that dental characteristics are extremely diverse, of the same order as mitochondrial DNA. Random matching occurred in less than 2% of cases; excluding individuals with no restorations increased matching to 99.9% for the detailed set and 99.8% for the generic set. He concluded that his research had shown that "detailed documentation of surface location for restorations does not significantly add to the discriminating power of an *ante mortem-post mortem* comparison when sufficient dental remains are present" (Adams 2003). This result is extremely important for the DFDS as it will affect coding decisions.

The computerization of matching has resulted from mass disasters to speed up dental forensic matching. Numerous forensic charting programs are now available e.g. DAVID, WinID, CAPMI (Al-Amad, Clement et al. 2007). Clement has noted that the time spent on data entry with such programs should be at a minimum to maximize the cost-benefit of computerization (Clement, Winship et al. 2006). This is in accord with Adams' finding that generic records are as useful in identification as detailed records. Difficulties may still arise with the identification of teeth as it is not always possible to determine which premolar or molar tooth is present. One solution is so-called 'packing' where teeth are moved into the most mesial position (Arneman 1992). This solution is not used in clinical EPRs as it does not concord with conventional workflow.

2.3.3 Soft tissue charting

2.3.3.1 Oral cancer screening

Roughly 400 people per year contract mouth and pharyngeal cancer in Ireland and of these 46% subsequently die (NCRI 2009). While it accounts for only 2% of cancers in the British Isles it is one of the commonest cancers in the Indian sub-continent. Risk factors include alcohol and tobacco consumption and the condition occurs more commonly in males over the age of 40. 20% of the area of the mouth accounts for 70% of the cancers (Cawson 2002). Clinical examination of the soft tissues of the mouth forms part of routine care.

Recording of oral pre-malignant lesions on paper records confers no particular advantage to the dentist or patient. Computerization offers the advantages that pre-screening

information such as tobacco and alcohol consumption can be gathered and decision support can prompt to give appropriate advice; timely recalls can be issued to ensure that lesions are monitored; recording of suspect sites is now possible on diagrammatic representations of the mouth and photos can be seamlessly integrated into the patient record to monitor lesion progress.

Ontologies such as ICD-DA can be used to collect information about the prevalence of diseases such as oral cancer; to track outcomes and to monitor the incidence of conversion from pre-malignancy to malignancy. However, at this time there is no agreement between vendors or instructions by the State to act in this manner. It is likely that this information will remain inaccessible despite the uptake of EPRs by dentists.

2.3.3.2 Periodontal charting

The dental service in the DF has an in-house periodontist and has an establishment of 3 hygienists. Patients are referred by Dental Officers to these clinicians for advanced periodontal therapy. The clinical information recorded by these specialists includes periodontal pocket charting. This data set is time-consuming to capture and is relevant not only to the periodontal specialists but also to Dental Officers for conventional treatment planning. Currently, these measurements are recorded on paper and photocopied when requested.

Pocket chart measurements may also be recorded using an electronic probe such as the InterProbe or the Florida probe (Magnussson, 2000). The measurements are fed to a computer using a proprietary software package (Machion, Andia et al. 2007). While literature is available that shows that the difference between manual and electronic capture is not statistically significant in trained users (Silva-Boghossion, 2008) there is no comment in the literature in relation to problems found by users nor is there any in relation to integration problems with other Information Systems.

2.3.4 Radiography

Dental records differ from medical records because the majority of dental records have radiographs attached that are necessary to diagnose decay and other pathology and conditions

(da Silva Neto, dos Santos et al. 2008). Comparison of serial x-rays is necessary to monitor the progress of carious lesions, in particular; thus, routine access to historical images is required. Other imaging modalities such as MRI, ultrasound and CT may be taken in dental hospitals and cone-beam CT has emerged in specialist implant practices in recent years (Roberts, Drage et al. 2009). X-rays are also a useful tool in forensic identification, especially in individuals who have no restorations (Adams 2003). X-rays are taken in the Defence Forces for diagnostic purposes following best-practice guidelines (RCSEng 2004) and are not taken solely as a forensic tool, although due regard must be given to their possible use in this manner.

The problems of interoperability, DICOM compliance and storage have already been considered. As Farman has discussed, silver-halide films may be readable decades after exposure and it is incumbent on the operator that the replacement digital system will be equally effective (Farman 2005a). Farman also noted that it is the data captured and not the associated technology that is the valuable asset thus appropriate time and money must be spent in its preservation (Farman 2005b).

Dental practice also differs from medical practice as dentists order, capture and report on the images collected. These images are at very high resolution (of the order of 25 line pairs per mm) and are used for diagnostic purposes (Whaites 2008). By contrast, medical x-rays are usually at low resolution (of the order of 10 line pairs per mm), are reported on by radiologists and where subsequently examined by a treating doctor it is in conjunction with this report and is not for diagnostic purposes. The significance of these processes is that the historical light box and specialist radiology workstations are a bench mark standard for examining x-rays (Kantor 2005). Standard PC monitors do not usually have the resolution necessary for dental x-rays which coupled with viewing in ambient light conditions may lead to a significant reduction in diagnostic quality (MacDonald-Jankowski and Orpe 2007).

2.3.5 Photography

Adams identified that radiography or photography are necessary adjuncts to charting in individuals who have no restorative characteristics (Adams 2003). Best practice guidelines in relation to radiation exposure in Ireland (and the UK) indicate that photography is the preferred

method of capturing this data (RCSEng 2004). Photography is also increasingly being used to record pre-op conditions and post-op results for medico-legal purposes. Photographs may also be sent to laboratories to aid in prosthesis fabrication or to specialist colleagues to aid in referral. Intra-oral cameras are common tools used in patient education (Christensen 2007) and as a diagnostic tool (Freedman 2008).

However, dental photography is technically difficult because each photograph is a medico-legal record (Ahmad 2009). Specific cameras with the correct technical specification are necessary for good spatial resolution and colour reproduction.

Integration of digital photographs into EPRs may also present difficulties. DICOM v3 has specifications for the storage of photographs to promote interoperability (Farman 2005b). The ADA has published Technical Report No 1029 (available at: www.ada.org Accessed 28 June 2009) that provides information not only on the technical aspects of the required cameras but also on database requirements, labelling and DICOM descriptors to promote interoperability. No similar standards have been adopted in Ireland.

2.3.6 3D models

All dentists take impressions to manufacture custom made dental devices for patients. Laboratory prescriptions for these devices must conform to the Medical Devices Directive (1994). Dental laboratories must keep a copy of the record process and justification after the work has been completed. There appears to be no stipulation in the Act that this must be a paper copy of the paper record but legal advice may have to be sought on this matter.

Study models of patient conditions are routinely taken and may constitute a significant part of the record in specialist practices such as orthodontic practices. It is now possible to digitize these records using laser light scanners (Vlaar and van der Zel 2006). Digitized models are commonly used by laboratories in the manufacture of Procera crowns (Brunton, Smith et al. 1999). In these cases 50,000 images are taken to reconstruct the images. Dimensional inaccuracy in digitizers has been assessed as being of the order of 1 µm (Persson, Andersson et al. 2008). This level of accuracy is sufficient to consider replacing study models with digitized

images. Reports that direct digitization of tooth surfaces is now possible pave the way for electronic transmission of impressions to laboratories (Birnbaum and Aaronson 2008).

Digitized images can be manipulated in ways that conventional models cannot. For instance, it would be possible to track rates of enamel wear using these models and a mathematical program. Digitized images might also be manipulated in applications such as trial preparations or determining paths of insertion.

2.4 Summary

Dental records are captured in an environment that requires the use of personal protective equipment and this affects the ability of operators to enter relevant data into the EPR. Dental records may be more difficult to digitize than medical records as they contain symbolic representations of teeth and x-rays at high resolution. A lack of standards and the reluctance of vendors to adopt DICOM and other standards have affected the interoperability of EPRs and ancillary devices. Considerable work has been done in the US to try to rectify these problems. The EU and Ireland are so far behind in these matters that it may be worth considering the adoption of the relevant US standards.

3 Design

3.1 Forensic charting

The Defence Forces invests considerable time and money developing the capacity to identify bodies *post mortem* by providing identification tags, by recording the presence of tattoos or other distinguishing bodily marks during medical examinations and by carrying out forensic dental charting. Heretofore, the forensic charting has been recorded on a paper records (AF205, LA30 and AF14). Thus forensic charting by the Defence Forces Dental Service is a high priority since this aligns our role with Defence Forces strategy.

The introduction of the dental module of the Personnel Management System (PMS) has led to the recording of some of the charting electronically. There are known deficiencies in the PMS and further development of the dental module is envisaged. In order to advise the IT element of the Defence Forces of the type of coding needed in the revised dental module it is first necessary to understand how forensic charting is carried out in practice. This is particularly important because standards for forensic charting do not exist. Certain conventions for charting have arisen that are taught in dental schools but there is wide variation. Levison's textbook for dental nurses is in common use in the British Isles and most dental nurses follow the charting used in the text (Hollins 2008). New restorations, such as implants, do not have any standardized format and even more variation in charting may arise.

Tooth surfaces, the materials used to fill them and ancillary conditions are recorded during forensic charting. Reference was made to the literature in choosing which conditions should be charted (Adams 2003). A standardized set was created and a trial was carried out in the DFTC following which modifications were made to the process. A copy of the standardized charting is available in Appendix A.

The standardized set was then used to collect forensic charting from four Dental Officers, a retired Dental Officer who acts as a full-time locum in one location and from five dental nurses. This represents 10 of the 13 personnel involved in forensic charting in the DFDS (100% of the Dental Officers and 70% of the dental nurses).

The format of forensic charting in dedicated forensic Electronic Patient Records (EPRs) (WinID, CAPMI, DAVID), commercial EPRs (Tab, Exact, Bridges, Panara) and the dental module of the PMS were also examined using this model.

The formats used to chart tooth surfaces, the dental materials used and ancillary conditions in forensic charting have been recorded. The results will be used to inform the coding of forensic charting in the PMS.

3.2 Content of dental EPRs

Standards for the format of paper charts do not exist and the inherent flexibility of paper charts allows them to be used by different operators in a variety of ways and for a variety of functions. For example, the Dental Service periodontist uses the same paper chart as general dentists despite the fact that different information is collected. Vendors have developed EPRs that mimic the appearance of a paper chart but do not have its functionality. Schleyer found that the result is that EPRs do not conform to clinical workflow and, in fact, generally hinder clinical workflow (Schleyer, Spallek et al. 2007).

The ADA has published a standard, ANSI/ ADA 1000, that details the structure of an EPR (Available at: http://webstore.ansi.org Accessed 02 Aug 2009). It details general information categories that allow for the systematic collection of information using "a process model…..divided into four parts: (1) obtain clinical data, (2) determine health status, (3) determine service plan, and (4) deliver patient care" (Schleyer, Spallek et al. 2007). This standard has not been adopted in Ireland or the EU.

Schleyer developed a so-called Baseline Dental Record (BDR) using these categories by consulting paper records, textbooks and US dental EPRs. The BDR contains subcategories and specific data elements as well as their associated collection method. For example, the Medical History category has the Past/ Present Illnesses subcategory, one of the questions is "Do you have any allergies?" and the answer is collected using a yes/no checkbox. The categories and subcategories in the BDR are outlined in Table 3 below.

Table 3: The categories and sub-categories classified in the Baseline Dental Record

Category	Title	Subcategory
1	Chief complaint	
2	Medication history	
3	Medical history	3.1 Past/ present illnesses
		3.2 health history
		3.3 Allergies
		3.4 Women only
		3.5 Vital signs
4	Dental/ social history	41. Dental history
		4.2 Social history
5	Hard tissue/ perio chart	
6	Intra-oral exam	
7	Extra-oral exam	
8	TMJ/ occlusion	8.1 TMJ exam
		8.2 Occlusion
		8.3 Parafunctions
9	Radiographic history/ findings	9.1 Radiographic history
		9.1 Radiographic findings
10	Physician info	
11	Alert summary	
12	Medical history update	
13	Consultations	
14	Systemic diagnoses	
15	Dental diagnoses	
16	Problem list	
17	Prognosis	
18	Treatment plan	
19	Progress notes	
20	Prescriptions	

Schleyer used the BDR in an attempt to objectively and quantitatively assess the content of US dental EPRs. Notwithstanding the fact that there is a certain degree of overlap, it may still be used for the same purpose to assess the content of commercial EPRs in Ireland. The BDR was adapted by removing category 5 (hard tissue and periodontal chart) as this element is examined in the forensic charting examination in this thesis in another format. The modified BDR is available for inspection in Appendix D.

The BDR has been used to examine the following commercial Information Systems: TAB dental (trial software downloaded); Exact (site visit to practice); Bridges (site visit to practice) and Panara (site visit to practice). These EPRs have the greatest market share in Ireland so this analysis encompasses the EPRs used by the majority of dentists in the Republic of Ireland. The BDR will also be used to assess the content of the dental module of the PMS. Inferences may then be drawn as to the development of the PMS and specifically, those areas that need to be coded.

The aspects which are of interest are: firstly, the information categories which the EPRs address; secondly, the extent to which the EPRs cover the specific categories and thirdly, the collection methods (whether by text, date, graphic etc). This will provide a high-level outline of the information categories covered by EPRs and, more pertinently, the categories that are not coded but left to the progress notes where the information is effectively lost (from an audit or management perspective). A proposed information model for the PMS will then be developed.

3.3 Analysing information flow in the DFDS

The dental module of the PMS is being developed as an EPR. The DFDS uses paper forms and the PMS to transmit information relevant to the business of dentistry throughout the DF. The clinical information categories necessary in an EPR will be examined in section 4.2 below. In this part of the research the associated administration will be examined at increasing levels of granularity to assess the types of data that are used. These can then be coded into the dental module of the PMS.

3.3.1 Mapping information flow in the DFDS using Army Forms/ PMS

The Defence Forces has an Information System that utilises Army Forms, Army Books (LAs), other paper documents and the PMS. The movement of these items has been modelled by mapping the form to the individuals who hold, carry, process and authorize them. A use case diagram modelling this information flow has been developed. The use case helps to identify the personnel involved in form use, associated problems and the potential for computerization.

3.3.2 Case studies and sequence models

Case studies and associated sequence models have been developed of four scenarios that help analyse the decisions and actions involved during the use of these documents. The key data elements important for coding can then be distinguished. Case studies are a useful means of analysing information flow as both the common and unusual situations can be modelled to identify the flow of data. The following case studies have been modelled:

1. A new patient attending the clinic
2. Carrying out an overseas forensic charting and risk assessment
3. Extracting a tooth in an emergency in a medically high risk patient
4. Providing a laboratory made prosthesis for a patient following the completion of specialist endodontics

These situations have been chosen as they encompass a reasonable range of a dentist's work and involve other agencies within and outside the Defence Forces. The information gathered has been classified according to the following categories:

- Actor
- Location
- Intent/ strategy
- Action
- Relevant documentation
- Breakdowns in workflow

The advantage of this approach is that the actions of each of the team members can be modelled to a very precise level of detail. Sequence diagrams have been developed for each case to model the flow of information.

3.3.3 Identification of data elements

The data fields in the Army Forms were identified and their distribution mapped. The data elements have been divided into demographic data, clinical data and ancillary data. The distribution, frequency and type of data element found in Army documentation will allow the coding of these elements in the PMS. The objective is to capture this information once at the appropriate point in care so that it is available for use in the many documents in current use.

3.4 IT, information management, governance

The IT infrastructure at each location has also been investigated since it is not possible to fully utilise an EPR if there are deficits in IT. Identifying these deficits will allow a report to be generated to the CIS Corps who action the purchase and provision of these items.

Handling medical data is associated with a duty of care to patients to protect that data. It must also be possible for the appropriate clinician to access data at the right time. The issues of information management and governance of data within the DFDS have been investigated in this part of the research. It should be noted that no attempt is being made to draw fine-grained statistical data from the results collected given the small sample size. It is sufficient to declare that general trends that affect policy can be determined.

Three questionnaires were developed to carry out these audits. They were adapted from the questionnaires published by Prof Alan Gillies on his website 'The Dental Practice Information Maturity Model' (available at: http://www.alangillies.com/dpimm/index.htm accessed 19 April 2009). The questionnaires were modified to make them more relevant to the DF. It was decided to use separate questionnaires for individuals, for location commanders and for the Chief Dental Officer so that policy matters in the DFDS could be directed at managers while user issues could be directed at individuals. A Likert scale was used to categorize responses.

A trial of the individual questionnaire was carried out in the DFTC with two Dental Nurses at that location. Their comments and an assessment of the trial led to the redesign of the questionnaires including a reduction in options on the Likert scale and an opt-out option for each question. The questionnaires are available for inspection in Appendices I, J and K.

3.4.1 DF policy analysis

The questionnaire in relation to DFDS policy was answered by the Chief Dental Officer. During the interview, it became apparent that certain matters were enterprise policy directed by the relevant branches of the Defence Forces and that specialist braches would have to be consulted to fully analyse these issues. The advice of a Defence Forces Headquarters CIS Officer was sought about matters of policy in relation to electronic records. The advice of the Legal Officer in the DFTC was sought in relation to the impact of civil legislation on Defence Forces policy.

3.4.2 Location audit

Questionnaires were directed at the Dental Officers responsible for each location during site visits to the clinics. All locations were visited during this review process. The clinic locations visited are indicated in Table 4 below.

Table 4: Dental surgery locations in the Permanent Defence Forces

Brigade	Location	No of surgeries
W Bde	Custume Barracks, Athlone	2
E Bde	Logs Base Hospital St Bricin's, Dublin	2
	Cathal Brugha Barracks, Dublin	1
DFTC	Curragh Camp, Co Kildare	2
S Bde	Collins Barracks, Cork	1
Naval Service	Haulbowline, Cork	1

3.4.3 Staff audit

Individual questionnaires were directed at Dental Officers, a retired Dental Officer and dental nurses during site visits to the clinic locations. The number of personnel interviewed and those available for interview (in brackets) are outlined in Table 5 below. 100% of the Dental Officers available for interview were interviewed and 70% of the dental nurses available for interview were interviewed.

Table 5: Occupations questioned by location

	Dental Officers Interviewed (strength)	Dental nurses Interviewed (strength)
W Bde	1 (1)	0 (1)
E Bde	1 (1)	1 (2)
DFHQ	1 (1)	0 (0)
S Bde	1 (1)	1 (1)
NS	1[1] (1)	1 (1)
DFTC	0 (1[2])	2 (2)
Total	5 (6)	5 (7)

Notes: 1 - retired DO; 2 - interviewer

4 Results and evaluation

4.1 Introduction

This section of the thesis examines the results of the research assessments. Section 4.1 reports on the format of dental forensic charting in paper charts and in dental Electronic Patient Records (EPRs). An evaluation of these formats and their potential applications within the dental module of the Personnel Management System (PMS) are then considered. The outcome is a set of coding recommendations for dental forensic charting in the PMS.

Section 4.2 examines the structure and format of information categories and sub-categories that are coded into commercial EPRs and the dental module of the PMS. The results highlight shortcomings in commercial EPRs. Specific information categories are then recommended for initial coding in the PMS.

The use of Army forms, books and other documentation is considered in section 4.3. Movement of information is modelled by constructing a use case. Case studies and associated sequence diagrams allow analysis of decisions made and actions taken when using Army documentation. The forms are then analysed at a high level of granularity to identify the key data elements in each form. Coding of selected data elements into the PMS will allow the business of dentistry in the Defence Forces Dental Service (DFDS) to proceed efficiently.

Finally, section 4.4 examines the IT infrastructure, data management policies and information governance policies in place in the Dental Service. Deficits have been identified in all areas that management in the Defence Forces (DF) must address.

4.2 Forensic charting

Forensic charting is a fundamental part of a dental EPR. However, the literature has identified certain paradoxes arising from the need to record dental charting: firstly, while the unique characteristics of a single tooth may be sufficient for positive identification, more commonly it is the case that greater detail does not aid in identification (Adams 2003). Consequently, there is usually a diminishing return from increased data entry to a forensic charting system (Lorton and Langley 1986). A second paradox is that decay is not useful for forensic identification

purposes despite the fact that the identification and treatment of decay is a driver of attendance by patients.

Thus it is possible to distinguish between charting collected for forensic purposes and that collected as a basis for treatment planning. In civilian practice the forensic charting allows clinicians to record dental and oral pathology; to treatment plan and to record restorations and other treatments provided. In the military context forensic charting provides a record should *post mortem* identification become necessary. Military clinicians may also require that the data collected acts for forensic as well as routine clinical purposes. The importance of this matter is that a decision has to be made at management level in relation to the type of charting that it is required so that appropriate coding of charting can be developed.

The coding of forensic charting by dental officers, dental nurses, the dental module of the Personnel Management System and commercial EPRs have been examined to analyse the coding that is in use.

4.2.1 Format of forensic charting by Dental Service personnel

Dental Officers and dental nurses were asked to chart specific surfaces, materials and conditions as outlined in Appendix A. A number of governance issues became apparent. Firstly, dental personnel are not conversant with the FDI tooth numbering system and this necessitated the use of the Zsigmondy system. Personnel will have to be trained in the use of the FDI system if it is to be adopted as a standard in the Defence Forces.

Secondly, there is no agreed or standardized mode for the collection of forensic charting. Some locations chart clockwise starting with the upper right third molar tooth; others chart in an anti-clockwise direction starting from the upper left molar tooth and other variations occur. The dental nurses collect the data called out by the Dental Officers and so develop familiarity with the local convention. However, this can cause problems with the inter-operability of dental personnel and may lead to transcription errors. For example, one Dental Officer asked that the charting be oriented towards the local convention rather than use the proposed format. The obvious solution is to declare a standard mode and the most logical method is to collect information according to the FDI pattern of tooth identification since it

numerically defines not alone teeth but quadrants of the mouth. Thus collection would begin at the upper right third molar and continue in a clockwise manner.

Thirdly, collection and transcription errors occur. These were apparent because the charting collected followed a defined, known pattern. An audit of accuracy undertaken on a component of DF personnel serving in Chad indicated that similar minor errors occurred in charting (Crotty 2008). Dental Officers are clearly unaware of these errors as chartings are transcribed by dental nurses and Dental Officers would not remember charting with enough degree of accuracy to pick up minor errors during a visual inspection of the transcribed charting. Computerization does offer solutions to this problem as it is possible to have two screens – one that the Dental Officer can see and one that the dental nurse can see – allowing the Dental Officer to see the charting being transcribed by the dental nurse as it is called out.

The results of the chartings provided by Dental Officers and dental nurses are shown in Appendix B. The charting on paper records is a mix of three types: symbolic representations, text and codes.

Dental charts are designed to be a symbolic representation of the teeth so it unsurprising that many types of restoration are recorded symbolically. In particular, there is a common symbolic representation used to record the filled surfaces of teeth without specifying the material or type of restoration used. For example, in Figure 6 below, the upper photograph shows an amalgam restoration in the upper right first molar; the lower photograph shows a tooth-coloured replacement in the same tooth (Available at: http://www.mysmile.com Accessed 21 June 2009) and the dental chart records the symbolic charting for both restorations. Note that the symbolic representation in the charting is identical for both restorations.

All the Dental Officers and dental nurses recorded fillings in teeth symbolically, although errors occurred. Tooth decay was recorded symbolically in a similar fashion. Some nurses were aware of conventions for recording different types of filling material - such as hatched lines for composites - but none used these representations.

Symbols were also used to record: teeth absent; retained roots; crowns; bridges and the movement of teeth. There was general agreement on the type of symbol used to record teeth absent and the movement of teeth but no general agreement for the other symbols used reflecting the lack of standardization in forensic charting.

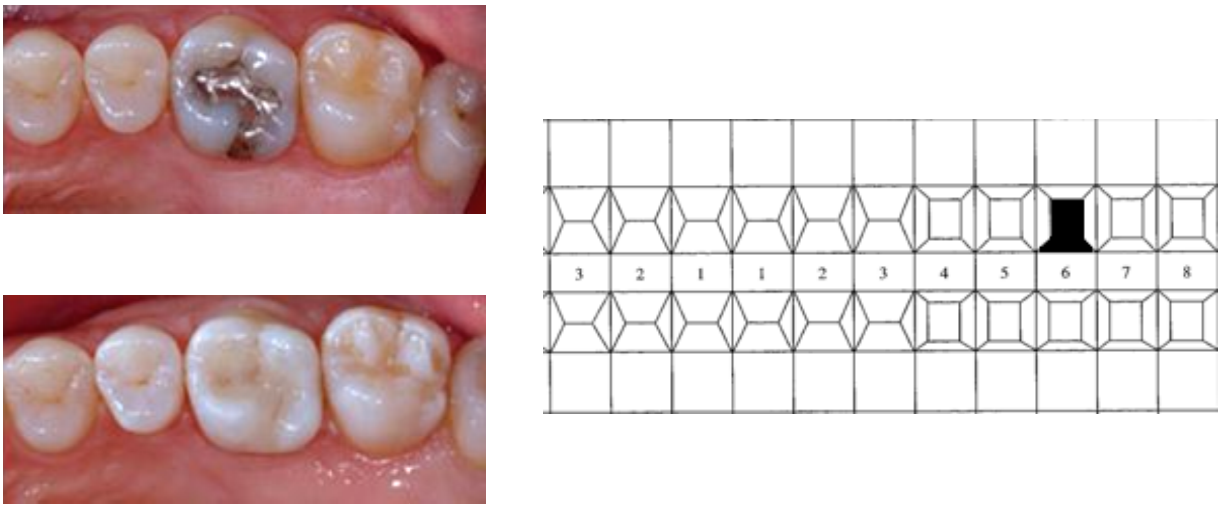


Figure 6: silver-amalgam restoration; composite tooth-coloured replacement and forensic charting

Text plays a significant role in paper based charting because conditions that do not have a known symbol or code can simply be written onto the record card. The flexibility of paper means that the text can be close to the appropriate tooth. The text can also be as long as is felt is needed for clarity.

Dental Officers and dental nurses recorded a number of items using text: retained root; crown; veneer; bridge; denture; implant; inlay; fissure sealant etc. In some cases, such as charting a supernumerary tooth or an implant, most personnel used text. In other cases, such as charting a crown, most personnel used a code and a single individual used text. The use of text demonstrates the inherent flexibility of paper records but is also highlights the lack of standards in forensic charting.

Codes are used in paper based charts as shorthand for well known items or procedures but these are commonly local conventions since no standards exist for forensic charting. Dental Officers and dental nurses use codes for partially erupted teeth and unerupted teeth and predominantly use codes for crowns, bridges and fissure sealants. However, without standardization confusion can easily arise. For example, the code 'RCT' is used by some dental personnel to record teeth that have root treatments present while others use the same code to record teeth that require root treatments. In another case, the code 'A' was used by a Dental Officer to refer to an artificial tooth, such as on a denture, but other dental personnel were unaware of the meaning of this code.

4.2.2 Format of forensic charting in EPRs

The forensic charting of the following eight Electronic Patient Records was examined:

- The dental module of the PMS
- Three dedicated forensic charting programs: WinID, IDIS and DAVID
- Four commercially available EPRs: TAB dental, Exact, Panara and Bridges

The surfaces, materials and conditions that dental personnel charted were used as a standard to collect data from the EPRs. The results of the chartings are shown in Appendix C.

The EPRs examined may be divided into two groups: those that are designed specifically as a forensic tool and those designed for general practice. The PMS may be regarded as a program in development for general practice. They may also be classified as programs that use codes for forensic charting and those that use symbols for forensic charting. Table 6, below, summarises the relationship between these two characteristics.

The four commercial EPRs and one of the forensic EPRs have the capacity to use symbols (Exact uses symbolic charting but also uses extensive associated coding) while two of the three forensic programs use codes alone. The PMS also uses codes and appears to have more in common with a forensic program than an EPR designed for use in routine dental

practice. The use of codes by forensic charting programs can be understood in the context of specific data entry that may not be relevant to routine care. It is also easier to carry out comparisons between records using codes rather than symbols.

Table 6: Classification of dental EPRs by content and function

	Codes	**Symbols**
Forensic only	WinID, IDIS	David
General clinic use	Exact, PMS	Exact, Tab, Panara, Bridges

As with paper charting, charting in electronic records is a mix of symbolic representations, text and codes. In the case of EPRs either symbolic charting or coding dominated as a charting type. While defining charting standards may reduce the need for text entry in an electronic record, it is not be possible to code all the dental conditions that may arise. Consequently, text is used in EPRs as an adjunct to the primary means of capturing data. In these cases, it takes the form of free text in progress notes, rendering such information of limited value for evaluative or research purposes.

In addition, text in progress notes is not located next to the appropriate tooth in the hard tissue chart and this reduces the ability of a dentist to scan a chart and form an impression of the hard tissue status. It means that the charting screen is not a complete forensic record as the progress notes must also be consulted. It may also require the entry of additional explanatory information. For instance, rather than writing “supplementary” at the appropriate place in a paper chart it may be necessary to enter “supplementary tooth between tooth 15 and tooth 14” in the progress notes of an EPR. The effect that this might have on the accuracy of charting is unknown and would depend on the number of conditions that are recorded symbolically or by codes and other factors such as patient demographic and practice type.

EPRs that use symbolic charting use the standard symbols for the filled (or decayed) surfaces of teeth that are in use in paper records and the symbols are immediately recognizable without additional training. However, where conditions lack standardization in paper records as, for

example, is the case for bridges and crowns, then standardization in EPRs does not exist and the meaning of the symbols used cannot immediately be understood. Figure 7 below shows a representative symbolic charting.

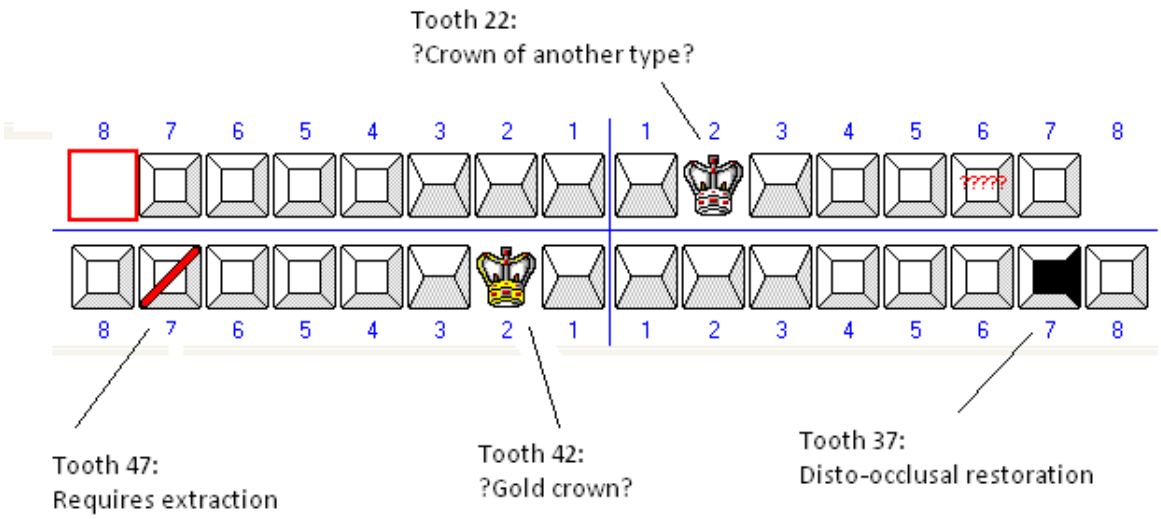


Figure 7: Representative symbolic charting in a commercial EPR

The symbolic charting in tooth 37 of a disto-occlusal restoration is the same as is found in paper charts as is the symbol in tooth 47 to indicate that extraction is necessary. However, the symbols associated with tooth 22 and tooth 42 can only be guessed at without instruction as to their meaning.

The five programs examined use symbolic charting to record a host of conditions including: sound teeth; absent teeth; crowns, veneers, bridges, dentures and implants; erupting teeth and pins and posts. However, no condition is recorded symbolically by all the programs because a mixture of symbols and codes are used. Thus, for example, dentures are recorded symbolically in the forensic chart by Panara and by Bridges; both symbolically and using codes by Exact; by codes alone by Tab, David, IDIS and WinID and not at all by the PMS. Standardization is clearly required.

Codes are used by all the EPRs to a greater or lesser degree. Two of the three dedicated forensic programs (WinID and IDIS) and the PMS solely use codes while one of the forensic programs (David) and the commercial EPRs use a mix of symbolic charting and coding.

Codes tend to be used for crowns, bridges, unerupted and partially erupted teeth. There is little general agreement between the programs as to the code to be used for a specific condition. For example, six different codes are used by four EPRs to record unerupted teeth and fourteen different codes are used by seven EPRs to record bridges present.

However, there is strong agreement between WinID and IDIS in relation to the types of codes that are used. The IDIS system was developed in 2006 by Chomdej et al using the guidelines of the American Board of Forensic Odontology (Chomdej, Pankaow et al. 2006). It appears to be a refinement of the WinID system with the inclusion of codes for implants, supernumerary teeth and impacted teeth.

4.2.3 Evaluation of forensic charting

Dental forensic charting of personnel is carried out in the Defence Forces in an environment where soldiers are required to attend for charting at various points in their military career. There is, therefore, an obligation to capture and hold an accurate, complete and usable forensic charting. In the Defence Forces, forensic chartings are recorded on paper, in the main, and in the dental module of the PMS. Commercial EPRs and dedicated forensic EPRs are an alternative to these systems.

The format of the chartings captured has already been considered. In this section the utility of the forensic chartings will be analysed in relation to each other using paper records in the Dental Service as a benchmark. The coding of these systems will be considered in relation to the features of an ideal coding *viz.*: simplicity; flexibility; ease of use; accuracy; completeness; uniformity and relevance. The aim of the analysis is to assess the functionality of the forensic charting of the dental module of the PMS and to assess whether changes ought to be made.

For the purpose of the evaluation, dental forensic charting has been broken into three components:

1. The methods used to record the six tooth surfaces as this is the fundamental component of a dental chart.
2. The methods used to record the six materials commonly used in dental restorations. This information refines the surface information captured.
3. The methods used to record twenty-one common conditions such as crowns and bridges that may be in addition to, or replace, the initial charting.

Table 7 below summarises the methods used to capture this information.

Table 7: Methods used to record forensic charting

	text	symbols	codes	none
SURFACES		Paper 98% Forensic 33% Commercial 100%	 PMS 50% Forensic 66%	Paper 2% PMS 50%
MATERIALS			Paper 6% Forensic 61% Commercial 21%	Paper 94% PMS 100% Forensic 38% Commercial 79%
CONDITIONS	Paper 22%	Paper 22% Forensic 12% Commercial 51%	Paper 44% PMS 57% Forensic 48% Commercial 37%	Paper 15% PMS 43% Forensic 52% Commercial 29%

The primary reason for holding a specialized dental chart is the tooth charting of which the tooth surface record forms the main part. No standard paper tooth chart exists although they are usually of a readily recognizable form corresponding to the anatomical surfaces of teeth. Dentists are used to considering these charts despite the dimensional translation required.

While the 2D chart may be considered the industry standard, Schleyer and others have called for 3D charting to remove the potential for “cognitive friction” (Schleyer, Thyvalikakath et al. 2007b).

On paper, symbols were used by personnel in 98% of cases to record tooth surfaces; the other 2% corresponded to a single individual who did not know how to record the buccal surface of a tooth. Effectively, symbols are always used by personnel to record tooth surfaces on paper where they are able to do so. It shows that symbolic charting is easy to use but requires appropriate training.

The problems associated with transcription and the accuracy of charting have been described (Adams 2003). The inherent flexibility of paper means that it is easy to chart in error. There is also significant variation in the amount and extent of box-filling in paper charting. This sometimes leads to confusion as to the exact charting. This problem can be solved by standardization.

Commercial EPRs and one of the forensic EPRs (DAVID) also use symbolic charting to record tooth surfaces. These follow the format of paper charts but no standard design exists. The advantage of using the format found in paper charts in EPRs is that dentists are used to looking at this type of charting but the disadvantage is that it is no improvement on the paper chart. Considerable training is required to use these systems and they are not always easy to use.

By comparison, two forensic charting programs, WinID and IDIS, use codes to record tooth surfaces. These codes are the shorthand for the anatomical surfaces involved and are in uniform use. They are simple and easy to use without additional training. These codes are used in forensic charting as they remove the transcription errors associated with paper charting. However, since dentists are not used to assessing dental health based on codes, their use and potential problems in a clinical environment is unknown. Further analysis of this subject is required.

The dental module of the PMS also uses codes for surfaces and follows the model of forensic EPRs as above. However, the coding has a significant shortcoming as it records the mesial (M), distal (D) and occlusal (O) surfaces but uses an asterisk (*) to record both the buccal

and palatal surfaces. In addition, the incisal surface has no code although the occlusal code may be used in this position. Consequently, the PMS cannot record an accurate forensic charting. The immediate action should be to code the incisal (I), palatal (P) and buccal (B) surfaces. In the longer term, research into the cognitive assonance or dissonance associated with the use of codes to record tooth surfaces in general practice should be considered since its effect on clinical care is not known and it is not desirable to replace a paper record with an EPR that affects clinical care.

One of the advantages of the paper record is that it can record multiple restorations on the same surface or on multiple surfaces. This is a feature that is not possible in EPRs. However, Adams noted that such fine detail is of little significance in forensic identification and that it is sufficient to group the surfaces together (Adams 2003). Dental personnel will need to be trained in this aspect of forensic charting so that the PMS can be used to collect accurate forensic charting.

The materials used in restorations form part of the clinical picture and affect care delivery. For example, there are significant differences associated with removing and replacing an amalgam filling and a gold inlay. However, on paper the vast bulk of this information (94%) was not recorded by dental personnel. When recorded, this information was recorded by codes. The implication is that this information does not affect routine care delivery and therefore is not usually recorded. Commercial EPRs follow the format of paper charts and do not usually record the material used (79%) although one commercial EPR (Exact) uses a combination of symbolic charting and codes and has the capacity to record the five most commonly used dental materials.

The forensic EPR DAVID does not have the capacity to record the materials used in restoration while IDIS and WinID can record five and six of the materials used, respectively. This reflects the paradox associated with data entry for forensic purposes: greater detail may allow identification from a single tooth but entering greater data entry reduces the efficiencies associated with EPRs. Where intact skeletal remains are found, recording of the materials used is superfluous. However, in the case of damage to the facial skeleton this information may aid

in the process of identification. On balance, it seems desirable to record the material used, where possible, for forensic purposes. Recording the restorative material would also allow long-term comparison of the survivability of the different dental materials.

The PMS does not record the restorative material used. A management decision should be made in relation to the collection of this information. One factor to consider is that codes are used in the PMS instead of symbolic charting. Coding additional information may help to overcome the problem of using a code-based system, particularly where text cannot be easily used as clarification. For example, coding a mesio-occlusal gold filling as MO-G clearly improves the clinical representation.

The codes used by the EPRs examined that collect this information are shown in Table 8 below.

Table 8: Codes used to record dental restorative materials

	WinID	**IDIS**	**Exact**	**PMS proposed**
Porcelain	H	H	P	P
Composite	E	E	C	C
Amalgam	S	S	AM	AM
Gold	G	G	G	G
Glass-Ionomer		E	GI	C
Non-precious metal	N	N		N

It is apparent from the table above that there is agreement between WinID and IDIS as to the codes used and these codes may reflect an emerging forensic standard. However, the codes are not generally intuitive to use although they are simple to use, confer accuracy and are amenable to expansion should new materials arise. The codes used by Exact are intuitive as

they match the first letter (or letters) of the appropriate material. As such, it would seem that it is less likely that errors would be made during data entry and this basic format should be adopted by the PMS.

Two refinements that may be suggested are: firstly, adoption of the letter N for non-precious metals (as in the WinID and IDIS coding) and secondly, duplicating the code C for composite and glass-ionomer materials (as in the IDIS coding) as both are tooth-coloured materials and it is sometimes difficult to distinguish between the two.

Twenty-one common conditions were queried during the forensic charting examination. While personnel did not record 15% of these conditions on paper, this reduces to less than 3% if the following are excluded:

- Sound teeth: these do not require intervention to record
- Pins and posts: these are not visible during visual inspection
- Dentures: these are not inserted during visual inspection as they hinder tooth surface visualization. In addition, they are removable and may be lost.

Excluding the above, dental personnel were able to record 97% of the conditions demanded, indicating the high degree of utility of paper charts.

22% of the conditions demanded during the charting exercise were recorded on paper symbolically. Certain conditions recorded symbolically on paper do not lend themselves to symbolic representation electronically – such as arrows showing the movement of teeth – and may be replaced by codes, although this is more unwieldy and will tend to be less complete or accurate. Where replacement occurs symbolically in the examined EPRs it tends to be generic and loses the specificity achieved in paper.

The commercial systems record 50% of the conditions symbolically. They generally symbolically recorded the conditions that are recorded symbolically on paper as well as other entities such as crowns and bridges. Forensic programs generally use codes (48%) although the

forensic program DAVID records some conditions symbolically and accounts for the low percentage of codes recorded by forensic programs symbolically (12%).

The PMS does not have the capacity for symbolic display but those conditions charted symbolically on paper generally are amenable to replacement by codes. For example, absent teeth, roots present and bridges can all be replaced easily by codes. The usual practice on paper of recording decay symbolically has been achieved electronically by having a separate line to record decay. This is another feature of the PMS that does not accord with normal clinic assessment processes or workflow and the effect that this may have on clinical care is unknown. It is by no means certain that this type of record would adversely affect clinical care as the arbitrary record of cavities and work completed in dental charts can lead to considerable confusion.

Significantly, 22% of the conditions were recorded as text on paper by DFDS personnel. Text was used to write in the condition or an explanatory word, usually in long-hand, where a symbol or code for that condition was not known. For example, 'fissure seal', 'inlay' and 'bridge' were written into the chartings. In total eleven of twenty-one conditions were written in as text by different personnel. It has already been noted that the text can be placed in the appropriate tooth box whereas this is unlikely to be the case in electronic records.

This demonstrates the deficit in standardized coding and the inherent flexibility of paper. It explains why paper records are able to record such a high percentage of conditions (greater than 85%) while, by contrast, the PMS, forensic EPRs and commercial EPRs record 57%, 48% and 71% of the charting conditions, respectively. None of the EPRs examined had the capacity to record an uncoded condition as text in the charting area; relevant text was placed as free text in the progress notes. The solution to this problem in the PMS is to have an extensive enough coding set to be able to encompass the types of conditions normally recorded as text on paper. In addition, the PMS should adopt the practice utilized by the commercial system Exact of using a code that indicates that a note about that tooth is in the progress notes - in the case of exact the code 'NOTETS' is used.

Codes form a significant part of the recording of dental charting conditions by all the records. On paper records, 44% of conditions were recorded using codes. Two conditions had no associated code (teeth absent and inlays) but were recorded symbolically or using text. In total, 29 codes were used for the 19 other conditions (where 'PE' and 'P/E' are regarded as the same code, for example) and there was some agreement between operators.

In one case a code ('Br') was used to represent two different aspects of the same condition (bridge and bridge retainer) and did not cause loss of precision. In another case, a code ('RCT') was used to represent two different but related conditions (root treated and needs a root treatment) and has the potential for greater confusion. In the case of crowns, eight separate codes are in use including a generic code ('Cr') and specific codes ('FGC', 'PJC' etc). Most of these codes are in common use and are easily understood. The meaning of other codes, such as FJC, can be derived by dental personnel while still others, such as VMK, are unintelligible without explanation. Clear definition of codes is the solution to these issues.

Commercial EPRs use a variety of codes for the 21 conditions with little agreement between them on the codes to be used. Commercial EPRs use codes in 37% of cases – the lowest of the groups - as they tend to try to maximize the use of graphical displays and use symbols for charting. Forensic charts have codes for 48% of the conditions with broad agreement between WinID and IDIS although the latter has more codes. The PMS relies solely on codes but these codes only cover 57% of the charting conditions. There is little agreement between any of the EPRs and the paper records on the format of codes which emphasises the need for standardization in the coding of dental forensic charting.

The challenge for the PMS is to replace well-known symbolic charting with codes. All of the coding systems in use may be used easily with training and they have enough flexibility to be able to encompass new conditions should they arise. However, given a lack of standardization it is necessary to make a judgement as to the best coding to use. The forensic EPRs use coding that is not intuitive to surgery personnel and these codes should not be adopted. Of the commercial systems, Exact makes extensive use of codes but most are not intuitive and Exact provides an on-screen menu of codes to overcome this problem.

One of the factors that has influenced the development of coding in the PMS has been the restriction on the number of characters that could be used to four characters. The IT branch of the DF has suggested that the restriction existed because of the use of low resolution monitors and that it may now be possible to extend the number of characters given the increase in monitor resolution. If this is the case it may be possible to copy the format of charting used by WinID. WinID uses a combination of surface, material and ancillary codes to record dental forensic charting. For example, a gold crown (covering all surfaces) would be recorded by WinID as the combination: MODBL – G – C. This would overcome some of the difficulties associated with the use of codes and would allow a clearer clinical picture to be formed.

There are a number of factors that should be considered in code development in the PMS. There are codes that are used in the PMS and on paper to chart the same condition and these codes should be unchanged. For example, partially erupted teeth are recorded as 'PE' by the PMS and on paper records. There are also codes in use in the PMS for which there are well-known and easily recognizable alternative codes in use on paper records. For example, the PMS code for crown, CRW, does not appear on paper charts and may be replaced by the code Cr.

In some cases a recognizable coding pattern emerges that would prompt changes to the codes. For example, PE is used as the code for partially erupted teeth in the PMS but U is used as the code for unerupted teeth. It would be preferable to follow the pattern and use the code UE which also has the advantage of being a well-known code used on paper.

Using the first few letters of a word as a code generally confers greater intuitive understanding of the meaning of the code. Thus it may be preferable to replace the code 'OII' for an osseo-integrated implant (usually referred to simply as an implant) with the code 'Imp'. This may be particularly useful where new codes are being introduced e.g. Sup for supernumerary.

In some cases existing codes may be reused where such reuse does not affect the meaning of the code but increases its granularity. For example, the code for Bridge on the PMS

('Br') can be adapted to use as bridge retainer ('Br') if a new code for bridge pontic ('Bp') is introduced because a bridge retainer is a component of a bridge.

It may be also be desirable to suppress certain codes to reduce the total number of codes to a manageable number. For example, the codes for present ('P'), sound treated ('ST') and sound untreated ('UT') would appear to have a degree of overlap and one or more could be deleted.

Finally, Schleyer has noted that dental EPRs do not generally code what dentists feel is necessary to allow clinical care (Schleyer, Spallek et al. 2007). An on going audit process is necessary to analyse the types of data that dentists wish to record so that the PMS may respond to changing clinical requirements by providing appropriate codes.

4.2.4 Application within the PMS

One of the significant restrictions that code-based charting in the PMS poses is that space restrictions mean that the information captured cannot be recorded on a single line. At present, the charting information is recorded on four separate lines, as can be seen in Figure 8 below. The components are:

1. Missing: records teeth present/ absent
2. Restored: records restorations present
3. Tooth wear and trauma: records fractured and worn teeth
4. Decayed: records cavities present

As has been discussed, this method of forensic charting is not used in routine care and may have an effect on clinical care. An attempt to make the chart accord with clinical workflow while also capturing the relevant forensic information is desirable. Suggestions of how this may be achieved are outlined below.

The PMS currently uses the Zsigmondy system of tooth numbering which means that it would be difficult electronically to track changes in tooth status with time. The PMS should adopt the

FDI system of tooth notation to overcome this problem. Since Dental Service personnel are not conversant with this system, it will be necessary to train personnel in the use of this tooth notation.

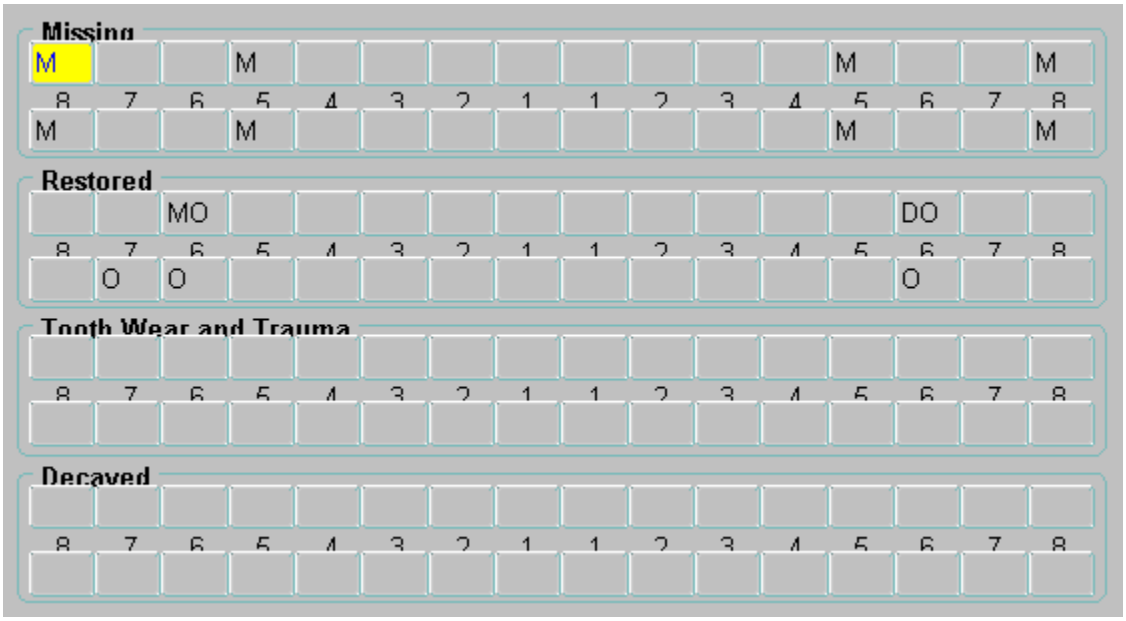


Figure 8: Screen capture of the forensic chart in the PMS

The Missing line in the dental forensic chart should be amalgamated with the Restored line to bring the forensic charting in line with workflow in the clinic (teeth are charting as absent during, not separate to, the forensic charting process). By default, in paper charts, a tooth is present unless marked absent and the same format can be used in the PMS. The advantage is that it is then possible to scan a line to form a clearer picture of hard tissue history. A compounding error in the present system is that a tooth can be charted as absent in the Missing line and a restoration placed in the same tooth in the Restored line.

The Tooth Wear and Trauma line should be renamed as Ancillary Information and used as a collection point for uncommon features. It would also be desirable to have a text box associated with this line that becomes highlighted when prompted by a code for a note (as

suggested above). This would give the chart the flexibility associated with paper and create a contiguous record.

The Decayed line should be moved to the centre of the three remaining lines as the Ancillary Information line is likely to be used less often. It would also be possible to code hard tissue pathology or suggested treatment into the Ancillary Information line that would be removed on completion of treatment.

Suggested codes for use in the Restored line are shown in Table 9 below. The final format of codes will have to be discussed with the IT branch of the DF and will depend on the number of character spaces that are allowed. In addition, it may be desirable to keep the number of characters used fixed and this may affect the suggested coding.

Table 9: Suggested codes for the Restored line

	Codes
Absent	Miss
Root	Root
Crown	Cr
Veneer	Ven
Bridge	Br, Bp
Denture	Dent
Implant	Imp
Inlay	Inlay
Fissure sealant	FS
Temporary	Temp
Pin	Pin
Post	Post
RCT	RFT
Partially erupted	PE
Unerupted	UE
Supernumerary	Super
Anomaly	NOTE

The codes proposed to record dental materials are shown in Table 8 above. As has been discussed, a combination of tooth surface code, material used code and ancillary code would provide a clearer clinical picture and should be adopted, if technically possible.

4.3 Format of dental EPRs

The modified Baseline Dental Record (BDR) created by Schleyer has been used to assess the information categories coded by the PMS and commercial EPRs. The extent to which the EPRs code these specific categories and subcategories has also been measured and the collection methods used has been noted (whether by text, date, graphic etc). The results have been used to suggest future development of the PMS. An information model has been proposed that is suited to the DF Dental Service and which draws on the information categories in ADA specification 1000.

Table 10 below summarises the number of categories and subcategories coded by the EPRs. There is limited coding of the information categories by all the EPRs examined.

Table 10: Number of categories and subcategories coded by examined EPRs

	PMS	TAB	Panara	Bridges	Exact
Categories (20)	5	9	6	7	10
Categories and subcategories (28)	5	12	9	10	13

The commercial EPRs tend to code categories relating to health history (medical history; medication history; physician information; alert summary and medical history update), treatment plans (usually in the form of service codes), progress notes and prescriptions. In particular, coding of the medical history is usually detailed and is accompanied by alert summary boxes or icons in all the commercial EPRs examined. A limited number of other

categories and subcategories are coded by these EPRs. For example, Exact has graphical representations of the intra-oral and extra-oral surfaces (BDR information categories 6 and 7).

The PMS has even more limited functionality than any of the commercial EPRs. Medication history and allergy information can be accessed outside the dental record by entering into the medical record. Similarly, prescriptions can be entered into the system but only for administrative purposes. Some elements of the treatment plan can be found in the dental module along with progress notes.

Of equal interest are the categories for which there is little or no coding. None of the systems code the 'chief complaint' category. This is invaluable in an organization such as the DF where tracking of such information may help to reduce morbidity. Most do not code the dental or social history both of which form part of long-term planning. For example, a history of smoking is an important factor in periodontal therapy while a history of failed composite fillings on anterior teeth may be a contra-indication to crown and bridge work.

Most EPRs do not code an extra-oral examination and none code tempero-mandibular joint, occlusion or parafunction records. Clinical data from these areas is not commonly recorded on paper charts. For completeness, it may be desirable to code these segments in a comprehensive EPR. Where rationalization of coding is an issue, these notes can be seconded to the progress notes.

By contrast, there is a legal requirement from the Radiological Protection Institute Ireland (RPII) to collect a justification for taking radiographs and to report on the results. A clear record of the frequency of exposure must also be taken to reduce exposure to patients. However, none of the EPRs code any of the radiographic categories. Coding of this element in the PMS is of high priority for the DFDS.

None of the EPRs code systemic or dental diagnoses nor do they create problem lists. Ideally, SNODENT and SNOMED would present a well-developed suite of dental and medical conditions that could be imported into an EPR as codes for diagnoses. However, assessments of the SNODENT dataset have concluded that it has not yet developed enough to be used in this manner (Torres-Urquidy and Schleyer 2006). There are a set of well-known dental pathologies

that form the bulk of routine clinical diagnoses in dentistry (for example, irreversible pulpitis, ANUG, pericoronitis etc) and these could relatively easily be initially coded into the PMS. In an organization such as the DF, diagnoses form an important link in the chain between chief complaint and treatments provided. It promotes audit and allows identification of unusual prescribing patterns. It can also allow the tailoring of resources by location such as the delivery of hygiene services or patient education.

In summary, the commercial EPRs rely on the progress notes to store the bulk of information collected in the clinic. Coding is concentrated in the medical history and in treatment planning. Schleyer's examination of US EPRs had broadly similar findings with low levels of coding in diagnoses, chief complaint and problem lists (Schleyer, Spallek et al. 2007). The conclusion is that commercial EPRs are not significantly better at collecting information than the PMS and that development of the PMS must also be in the areas that are patently deficient in commercial EPRs.

Table 11: Format of field coding in EPRs

	Text	Yes/No	Integer	Date	Other	TOTAL
BDR	**181**	**193**	**5**	**21**	**20**	**420**
TAB	27	45		18	33	123
Panara	28	20	1	13		62
Bridges	31	20	1	13		65
Exact	33	19	1	19	46	118
PMS	21		1	18		40

Table 11 above summarises the format of coding in data fields in commercial EPRs and in the PMS. It also shows the number of fields coded of each type. In the BDR about half the questions are coded as yes/ no answers and are concentrated in the past/ present illnesses (104) and dental history (42) subcategories. In the examination carried out by Schleyer on US commercial EPRs, an average of 174 fields were coded by EPRs (Schleyer, Spallek et al. 2007). As can be seen from Table 11 above, the commercial EPRs examined in this work code far fewer fields, at an average of 92 fields per EPR. Tab and Exact code intra-oral and extra-oral examinations graphically and this accounts for 77 of the fields recorded by these EPRs. Removing these fields reduces the average number of fields coded by all the EPRs to 72 fields per EPR. If the date fields are removed then this average reduces to 60 fields per EPR. Very few of the fields present in the BDR that correspond to clinical data are coded in the EPRs examined.

These results show that not alone are whole categories not coded by EPRs but that the coding tends to be concentrated in a small number of categories. Very little clinical information is coded and a significant proportion of the coding relates to the capture of ancillary information such as dates. The coding reflects the general practice setting where these systems are usually used where the emphasis is on information collection for accounting purposes. The coding in the PMS is almost completely related to ancillary capture by the progress notes. The coding of information is remarkably deficient in commercial EPRs and they should not be regarded as a benchmark for the development of the PMS. Consideration of the types of fields that are necessary in the PMS and their format may be better adjudged from the BDR.

Having considered the format of commercial EPRs and the BDR it is possible to plan the format of the dental module of the PMS. There is a certain degree of overlap in the categories in the BDR and these can be rationalized in the PMS. The needs of the DFDS are also different to general practice and a greater emphasis needs to be placed on certain categories (reason for attendance, for instance).

It is recommended that the following categories of information should be initially coded by the PMS:

1. Demographic
2. Medical history
3. Reason for attendance and problem list
4. Social history and dental history
5. Clinical exam
6. Radiographic exam
7. Dental diagnoses
8. Treatment plan
9. Procedure codes
10. Progress notes

The relationship between these categories and the typical information collection workflow is summarized in Figure 9 below.

These categories and data fields will form the clinical aspects of a dental module of PMS designed to replace the paper record. However, in the Defence Forces there is significant administration associated with the business of the Dental Service that may impact on the coding of the PMS. For example, every soldier works in a unit that has an associated cost code centre number and this number is needed when seeking financial sanction to refer patients for high-risk procedures. These issues will be analyses in section 4.3 below.

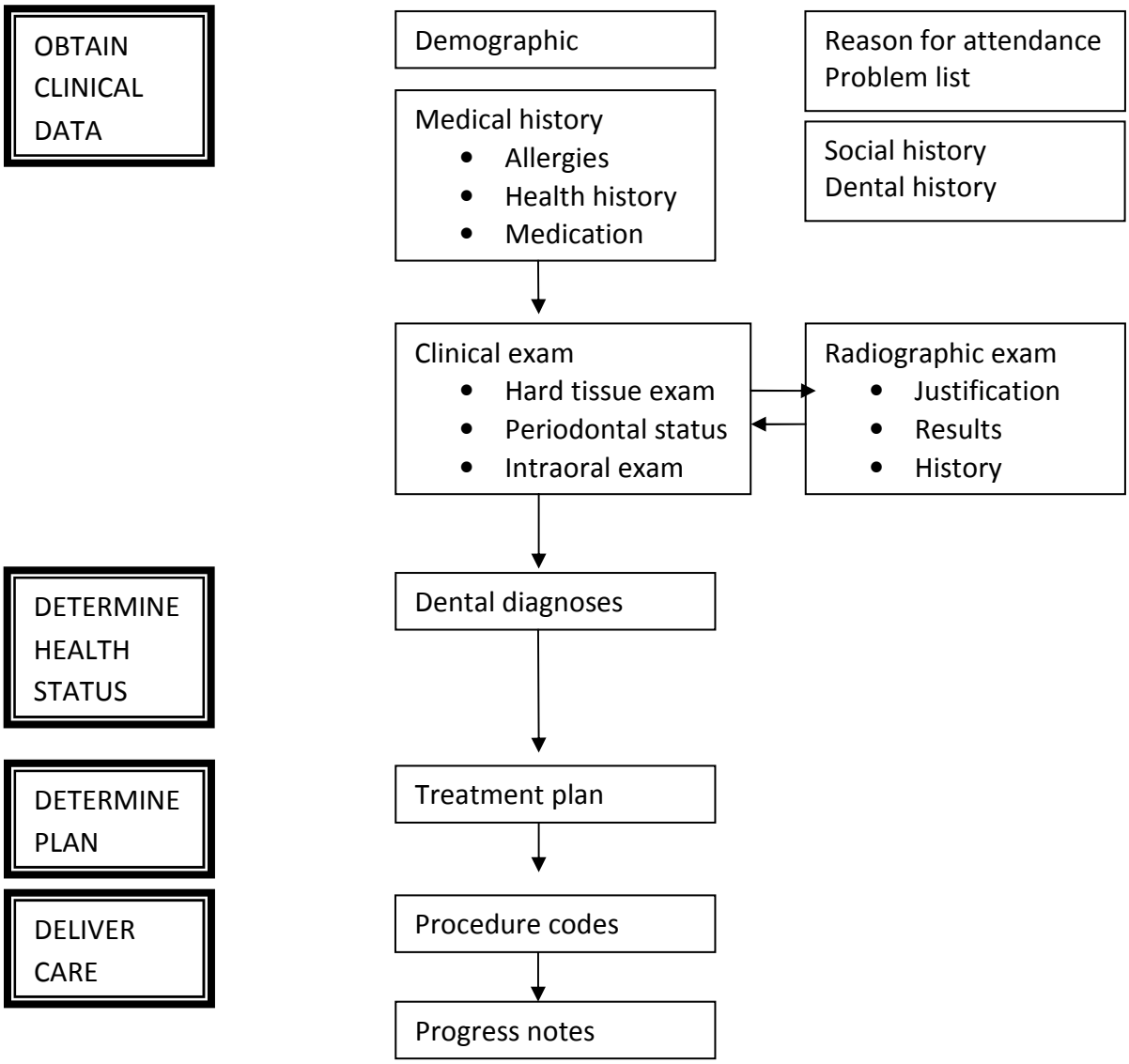


Figure 9: Relationship between information categories and workflow

4.4 Information flow in the DF

Along with the dental record card - Army Form 205 (AF205) – there are 16 other Army Forms, Army Books (Leabhar Airm) and documents used in the business of dentistry in the Defence Forces. Some forms are fully in use (e.g. AF207, the form to access civilian dentists) while others have fallen out of use (e.g. AF335, the dental inspection report); certain forms are vouchers for treatment or services (e.g. the referral form to the hygienist) while other forms have a legal requirement to retain a paper copy (e.g. LA27, the drug prescription form). The forms in use are listed in Appendix E.

In the first instance, the movement of these forms and books has been modelled by creating a use case for the business of dentistry. The use case helps to identify the personnel involved in form use, associated problems and the potential for computerization. Case studies and associated sequence models have been developed of four scenarios that help analyse the decisions and actions involved during the use of these forms. The key data elements important for coding can then be distinguished.

Finally, in this section, the forms have been analysed at a high level of granularity to identify the basic data elements in each form. A particular aim is to identify data elements that can be coded once but used many times; that is, data elements common to multiple forms and involved in workflows that lend themselves to computerization. Recommendations can then be made as to development of the dental module of the PMS.

4.4.1 Use case

The use case for the business of dentistry in the Defence Forces is shown in Appendix F. What is of interest is the number of agencies involved in the delivery of dental treatment in the Defence Forces:

1. Military dental surgeries: direct delivery of care; authorization of high-risk procedures that need prior financial sanction; assessment leading to treatment in another location (civilian general dentists, civilian specialists and military specialists)

2. Civilian dentists: general dentists are accessed by using AF207 as a voucher; specialists by prior financial sanction; hospital dentists using AF715 as a voucher
3. The unit Company Office: issue relevant forms and books; use the PMS to log absence for medical reasons; Company Commander authorises use of AF207
4. Pharmacies: the military prescription LA27 is a voucher for access to free medications at military and civilian pharmacies
5. Defence Forces Headquarters: permission for financial sanction is provided by senior officers serving at this location; management reports (AF221 etc) are routed to the Chief Dental Officer
6. Department of Defence: sanctions financial expenditure including AF207s

In the following section, case studies are analysed. These look at the use of these documents at a higher level of granularity. This will help to identify the decisions and actions taken by personnel and will aid in the coding of the PMS as these activities will involve the use of specific data elements.

4.4.2 Case studies

Four case studies were examined in the course of this investigation:

1. A new patient attending the clinic
2. Carrying out an dental forensic charting and risk assessment for a soldier intending to serve overseas
3. Extracting a tooth in an emergency in a medically high risk patient
4. Providing a laboratory made prosthesis for a patient following the completion of specialist endodontics

These cases were chosen as they encompass the routine and less common aspects of clinic workflow. An example of one of the cases studies and the associated sequence diagram is

available for inspection in Appendices G and H. Aspects of the workflow that may affect coding decisions are discussed below.

There are forms in use that do not lend themselves to computerization because they are used as vouchers to external organizations that are not in a position to send and receive this data electronically, notably the AF207 used by general dental practitioners. However, the coding of the PMS should be mindful of the potential for digitization in the future.

Other forms or books are in use by multiple military clinicians (for example, the LA30 medical book is used by Doctors, Nurses and Medics) or other personnel (for example, the SAD document is uses by the overseas and home unit and by Doctors). This implies that there would have to be a management decision to change at a level outside and above the level of the Dental Service. Some of these books and forms have been in use for decades and the problems of legacy data as well as the problem of resistance to change can be expected. In addition, it is often simpler to use paper documents than to access them electronically and where large amounts of data are stored in summary form (as in the LA30) this may particularly be the case.

The case studies show that relevant clinical information is commonly recorded in documentation outside the treatment notes. The reason for attendance is usually recorded in the appointment diary by the reception staff but this information is not readily available to the Dental Officer as it is held in the reception area. Incorporation of this specific information category into the PMS was recommended in section 4.2 above. The information is already being captured in an unordered fashion and should not adversely affect workflow.

Other aspects of the clinical cycle are not collected or not recorded. For example, the results of soft tissue exams feature rarely on paper records. A correctly coded PMS could allow some element of decision support by demanding certain information and thus forcing changes in behaviour. Cancer screening, radiographic audit and recording of diagnoses are all information categories poorly recorded at present that effective decision support could address. Computerizing the radiology request form, AF487, as a request within the radiographic category in the dental module of the PMS would be particularly useful in this regard.

Clinical information is also recorded in publically available documents: in the personal administration handbook (the LA30); in the clinic daybook (the AF206) and in sanction forms. These documents may pass through the hands of many personnel during processing or handling and this may be of particular concern in a small community. An EPR could improve confidentiality in these circumstances. In one case (the LA30, personal clinical administration book) the document expressly states that clinical information is not to be recorded but dentists continue to do so in summary form as they are following the work patterns of many decades. Thus an EPR may improve workflow by removing steps in the workflow that are now redundant.

Patients also expend considerable effort accessing paper documents. One document, the personal administration document, the LA30, may be accessed multiple times during a single treatment plan. Accessing this document can be difficult as it must be issued in the Company Office of the home unit and these offices are not always manned. Personnel may intentionally avoid collecting their LA30 in order to circumvent the difficulty of getting and returning this document. In fact, this book has not been needed in the dental service since the introduction of the PMS as the associated administration is now recorded on the PMS. However, recent changes in the operation of the civilian dentist referral form, the AF207, mean that there is now no means of communicating clinical information to civilian dentists except through the LA30. Solutions to these types of problems will have to be considered.

It is also clear from the analysis that considerable duplication of data occurs especially of demographic data. Medical history sheets; consent forms; SAD documents; single charting documents (AF14); additional clinical paper records (AF205); prescriptions (LA27); lab prescriptions (AF215); sanctions etc all require demographic details to be entered. It would be of interest to note the number of times a day this type of data is duplicated, on average. As the number of dentists in the Defence Forces dwindles there is increasing pressure on the remaining Dental Officers to carry out forensic chartings, particularly in the Brigade locations of Cork, Dublin and Athlone. These are associated with single-use documents such as the SAD and

AF14 that capture demographic details. Time savings are clearly possible by correctly coding this type of data into an EPR.

The associated problem of duplication of clinical information is more problematic. Duplication is associated with errors; the problems associated with duplicating clinical information in paper notes and electronically were noted by Schleyer (Schleyer, Spallek et al. 2007). Duplication of clinical information takes place in the Dental Service especially in dental forensic charting where a forensic chart is held in the personal administration book, the LA30; in the single-use forensic chart, the AF14; in the patient record card, the AF205; in the annual medical form and on the PMS. Clinical information is also recorded in general on the clinical record card, the AF205 and then a summary is placed in the personal administration document, the LA30 and on the daily work record, the AF206. The treatments completed are then duplicated on the work report to the Chief Dental Officer, the AF221. These actions are not a good use of time or resources and as mentioned above may also breach patient confidentiality.

An additional problem associated with generating multiple documents is the problem of storage and misfiling. The Defence Forces has a population that undergoes more rapid turnover than the general population because personnel retire at a comparatively young age, sometimes after relatively few years of service. Effective computerization of certain forms would greatly reduce these problems.

The case studies indicate that altering certain work practices and digitizing certain documents would confer benefit on the workflow of the Dental Service. The proposed actions are detailed below. It should be noted that the administration associated with the business of dentistry can only successfully reduce its paper burden if the dental record card is first digitized in the mode suggested in section 4.2 above.

Computerizing the dental record card (AF205) will immediately suppress the form AF14, the single use dental forensic record. It would also remove the need for the personal administration book, the LA30, although some means of communicating this type information to civilian dentists would then have to be considered.

Internal referrals to hygienists, periodontists and oral surgeons through the PMS should also be considered. Worklists associated with referrals can easily be created which can also be used to monitor demand.

The medical history form can be replaced completely by a computerized version. Some debate seems to exist as to the exact legal position in relation to recording patient signatures on medical history forms and it is for this reason that many commercial EPRs scan medical history forms into the EPR. Scanning signed consent forms is certainly a factor in the development of a paperless office and if such technology is in place it may well be easier to use it for medical history forms as well. Certainly, the design should be coded so that the medical history form is not generic when print but instead has the relevant patient demographics included.

There is a legal requirement at present to have a hard-copy, signed prescription. However, the PMS should move to the position where the prescriptions form (the LA27) is generated electronically and then printed off and signed to comply with current legislation. Changes in legislation would then allow these transactions to be generated electronically. A similar condition attaches to the laboratory prescription. In this case because reasonably detailed hand drawings are often included in the prescription it would be better to keep the paper prescription. It should also be noted that these documents are also sent to external agencies.

The process associated with seeking financial sanction would seem particularly suited to computerization. The main bulk of the record includes demographic details and then is followed by approval from a succession of authorities: clinician; Chief Dental Officer; Director of the Medical Corps and the Department of Defence.

The LA9 co-payment book orders the deduction of appropriate co-payments for dentures and other prostheses and is directed solely at Officers/ Soldiers pay in the Department of Defence (similar deductions are made for certain items of clothing). This document should be computerized not least because deductions using the paper records can take months to be processed.

Creating an expanded function PMS that includes procedure codes for treatments would allow the creation of daily worklists to replace the paper summary, the AF206, and weekly worklists for reporting to the Chief Dental Officer, replacing the AF221.

The recommendations above, if followed, would result in ten of the seventeen forms associated with the business of dentistry being computerized or suppressed. The computerization of a further three forms would depend on decisions outside the Dental Service (for example, the computerization of the sanction form). Four of the seventeen forms act as vouchers for external services and if digitized must be printed to be used. Of these, the laboratory prescription (AF215) could only contain demographic data as the PMS does not have the capacity to generate graphical representations. A summary of this position is given in Table 12 below.

Table 12: Proposed retention or replacement of Army documents

Paper records needed	Dictated by DF policy	Incorporate into PMS
AF715	AF487	Medical history
AF207	Sanction	Hygienist referral
AF215	LA9	Return from hygienist
LA27		AF14
		AF221
		AF206
		AF335 (in process)
		SAD (in process)
		AF205 (in process)
		LA30

At present only three forms are in the process of computerization: the dental record card (AF205), the dental inspection report (AF335), and the overseas administration document (SAD). These may be differentiated as two documents used solely within the dental service

(AF205 and AF335) and one document with multiple users (SAD). There is a risk in these types of development that the computerization will develop in a piecemeal fashion. The challenge is to develop a change management plan to integrate elements already computerized into a holistic program.

4.4.3 Identification of data elements

The data fields in the Army Forms were identified and their distribution mapped. A list of the documents and their associated number, where available, is shown in Appendix E. The data elements have been broken down into demographic data, clinical data and ancillary data. The distribution of the demographic data is displayed in Table 13 below.

Table 13: Distribution of demographic data in Dental Service documents

	Army no	Rank	Name	Unit	Tel no	Date	DOB	Cost code
CLINICAL RECORDS								
LA30	✓	✓	✓	✓		✓	✓	
Hygienist referral	✓	✓	✓	✓	✓	✓		
Hygienist return	✓	✓	✓	✓		✓		
AF14	✓	✓	✓	✓		✓		
AF205	✓	✓	✓	✓	✓	✓		
Medical history	✓	✓	✓	✓	✓	✓	✓	
VOUCHERS/ FINANCIAL								
AF715	✓	✓	✓	✓		✓		
AF207	✓	✓	✓	✓		✓		✓
Sanction	✓	✓	✓	✓		✓		✓
LA9	✓	✓	✓	✓		✓		
PRESCRIPTIONS								
AF215	✓	✓	✓	✓	✓	✓		
AF487	✓	✓	✓	✓		✓		
LA27	✓	✓	✓	✓		✓		
RETURNS								
AF221								
AF206	✓	✓	✓	✓		✓		
AF335	✓	✓	✓	✓		✓		
OVERSEAS								
SAD	✓	✓	✓	✓			✓	

There is widespread use of the same type of demographic data in the documents in use in the Dental Service. Army number; rank; name; unit and cost code centre are all coded into the PMS. Sex and home address are also routinely recorded by the PMS and while these data elements are not routinely used in the dental service, knowing the home address of a patient may be useful when referring to outside agencies.

Date of birth is recorded by the PMS as it forms part of the medical grading but appears in a truncated form (year only). It should not present a great difficulty accessing, displaying and using this data in the dental module of the PMS.

A contact telephone number is recorded on the patient record card; on the medical history sheet and on referral forms. It is also recorded on the appointment diary in case alterations to appointments need to be made. This data element is necessary for the smooth functioning of a dental clinic and should be coded into the PMS.

The distribution of the data associated with clinical functions is displayed in Table 14 below. A number of the elements have already been coded by the PMS: dental chart; CPITN; Dentures present; disposal and dental grade. Procedure codes have also been selected and coded although they are not currently in use. The outcome measurements for periodontal therapy may be broken into three classes (successful, limited success and failure) and thus can be easily coded.

Free text is used on paper records to adapt the relevant document to preferred use. In some cases (LA30, AF206, AF14 and AF335) the free text corresponds to elements that have been coded (dental grade, procedure codes, clinical disposal). In other cases (sanction, AF487, LA27) the free text will become redundant when coding of the clinical module is complete (e.g. diagnoses, list of procedures, list of drugs).

The radiology report form, the AF487, has a section for requested procedure and a section for the returning report. The procedures can be easily coded as there are a finite number used in the dental service. The report may be stored as a radiology report in the appropriate radiographic history category.

Three forms require further inspection of the types of free text used: the dental record card (AF205), the hygienist referral and the hygienist return. The latter two forms are coded to a large degree but the disposition of the free text is unknown. The dental record card might be expected to contain significantly variable data. Further research is warranted.

Table 14: Distribution of clinical data in Dental Service documents

	Dental chart	CPITN	Dentures present	Treatment plan/ procedure codes	Outcome	Disposal	Dental grade	Free text
CLINICAL RECORDS								
LA30	✓	✓	✓			✓	✓	✓
Hygienist referral	✓	✓		✓				✓
Hygienist return					✓			✓
AF14	✓	✓	✓					✓
AF205	✓	✓	✓	✓	✓	✓	✓	✓
Medical history								✓
VOUCHERS/ FINANCIAL								
AF715								
AF207								
Sanction				✓				✓
LA9								
PRESCRIPTIONS								
AF215				✓				✓
AF487				✓	✓			✓
LA27				✓				✓
RETURNS								
AF221								
AF206				✓		✓	✓	✓
AF335				✓			✓	✓
OVERSEAS								
SAD					✓		✓	

The distribution of the ancillary data elements is shown in Table 15 below. The authorizing person refers to the practice on Army Forms of seeking the signature of the appropriate authority. For example, the hygienist may sign a treatment return; a Dental Officer may sign a treatment record (AF205), a prescription (LA27) or a hospital form (AF715) and a Company commander may sign a sanction to see a civilian dentist (AF207). It would therefore, be necessary for the authorizing person to log onto the PMS to assign this authority electronically.

Table 15: Distribution of ancillary data in Dental Service documents

	Voucher	Financial	Civilian clinician	Authorizing person
CLINICAL RECORDS				
LA30				✓
Hygienist referral	✓			✓
Hygienist return				✓
AF14				✓
AF205				✓
Medical history			✓	✓
VOUCHERS/ FINANCIAL				
AF715	✓		✓	✓
AF207	✓		✓	✓
Sanction		✓	✓	✓
LA9		✓		✓
PRESCRIPTIONS				
AF215			✓	✓
AF487	✓			✓
LA27	✓			✓
RETURNS				
AF221				✓
AF206				✓
AF335				✓
OVERSEAS				
SAD				✓

As for the collection of details relating to civilian practitioners, in the case of some forms a finite number are on tender agreements (civilian dentists, recorded on AF207 and dental labs recorded on AF215) and there are relatively few dental hospitals and specialist colleagues to

whom a dentist may refer. Therefore these details could be easily coded into the PMS to allow insertion into the appropriate forms.

The LA9 and sanction forms record the costs associated with procedures but this is simply a matter of creating a numeric field. A number of other forms act as vouchers and the capacity to print off the details on screen must be incorporated. This is the case for AF715, LA27 and AF207. In the case of the hygienist referral forma and the radiographic prescription form, these may be suppressed by the correct coding of the clinical system.

In summary, significant duplication of data fields occurs in paper forms in the Defence Forces Dental Service. During days when mass chartings are scheduled this can significantly affect workflow. It is common on these days for a Dental Officer to be accompanied by two dental nurses, one for administration and one to aid in the clinic. The bulk of the associated administration involves filling in AF14s, duplicating chartings in the LA30 and recording attendance in the daybook (AF206). Coding the elements identified above would significantly improve patient throughput and is likely to reduce duplication and transcription errors.

4.5 IT management, information management and governance

4.5.1 IT management

The paper based management system in use in the Defence Forces since the establishment of the State has been transformed over the last two decades by increasing use of information technology. A stock management system, the Inventory Management System, was introduced in 2001 and was replaced in 2006 by a new package, the Management Inventory Framework (MIF). A human resources (HR) package, the Personnel Management System (PMS), was introduced in 2006 to manage the administration relating to serving personnel. A dental module exists that has progressed in capacity over time to include dental charting, fitness classification and management reports. IT has been introduced into the dental surgeries to allow access to this module. This research has addressed the issues of IT availability and appropriateness; DF wide and local policies in regard to IT management; staff training and staff

capabilities. The aim is to determine the IT policy, training and hardware requirements in the DFDS.

The following locations were examined:

- No 2 E Bde: LBH St Bricin's (1 surgery); 'Wing' LBH St Bricin's (1 surgery); Cathal Brugha (1 surgery)
- No 4 W Bde: Custume Barracks (2 surgeries)
- No 1 S Bde: Collins' Barracks (1 surgery)
- The Defence Forces Training Centre: Curragh Camp (2 surgeries)
- Naval Service: Haulbowline (1 surgery)

The results are recorded in appendices L, M and N.

4.5.1.1 Hardware

Five of seven locations have a PC at some point in the clinic. In each of these locations the PC is connected to the Intranet. This allows access to the MIF for processing of bills and to the PMS, where required. All the PCs have ancillary printers but no location has access to a scanner which is usefully used in practices to record or copy medical histories, referral letters and other documents. Dual printer/scanners are relatively cheap and easily available and should be purchased where possible as an alternative to printers.

Only one location has access to the Internet and this is through a PC that is connected to the digital x-ray server. The Internet is a vast repository of medical knowledge and is an invaluable tool for clinicians trying to keep core skills up to date. Access to dental journals, both free and by subscription, is easier, more complete and allows topic-specific searches. Internet access, while desirable, is subject to policy review by the CIS Corps.

No PCs are available to clinicians at the point of care. Currently, accessing the PMS entails location change, bypassing user access controls and additional time and effort. These factors make the PMS unused and effectively unworkable. This is reflected in the high number

of personnel classified as unfit on the PMS (nearly 100%) despite the high numbers seen, made fit and classified as fit on paper. IT delivery to allow the dental service to access the PMS is a prerequisite to transition to an EPR.

While literature from the US suggest that dental offices have begun to 'look like technology parks' (Schleyer 2004), anecdotal evidence from Ireland suggests that Irish practices lag behind in relation to implementation of digital technology. In the DF, only one piece of digital technology is in use – a digital x-ray system in operation in the dental surgery in Custume Barracks, Athlone. This is a stand alone system, not integrated with the PMS. Its operation has highlighted some important issues in relation to DF policy implementation.

At DF Dental Service level, policy in relation to data protection is abrogated to the CIS Corps, who have the expertise and mandate to act on such matters. Data saved onto common drives is backed up onto central servers and anti-virus software is downloaded onto PCs connected to the Intranet. Dental Officers follow best practice where they are compelled to do so by accessing or utilising software under the control of the CIS Corps. However, where central control is absent, poor practices are common. In the case of the digital x-ray system, backup is by means of a tape drive with 5 tapes available for multiple backups. The backup is carried out in a sporadic manner and tapes are kept beside the server exposing the data to the same risk of damage through fire or flood. No log of backup activity was available at the location and at the time of examination many months had passed since the last backup was performed. Similarly, Dental Officers write referral letters using Word and keep copies on local drives instead of common drives; one issue raised was the possibility that sensitive medical data could be accessed by unauthorised personnel on the common drives.

The associated question of appropriate anti-virus software is highlighted by the stand-alone digital x-ray system. The attached server is linked to the Internet to allow remote servicing of the software. An *ad hoc* arrangement for anti-virus protection has emerged. Certainly there is no protocol for the management of firewalls or anti-virus software in the PC which is exposed to the greatest threat of data corruption in the Dental Service as no others have access to the Internet.

An additional point of interest is the fact that this server was provided with a battery to protect against an interruption in the power supply. The server is frequently powered off and reliance on the battery for data integrity must be questioned.

A number of conclusions and recommendations arise from this examination. Firstly, the IT required at each location is outlined in Table 16 below. Recruitment of additional Dental Officers would necessitate delivery of further IT resources. Liaison with CIS personnel will be necessary to ensure that computer access points are placed in ergonomically efficient positions.

Table 16: IT requirements by location

Location	PCs at point of care	Admin PCs	Ancillary Equipment	Infrastructure (cabling etc)
No 1 S Bde	1	0	0	Y
Naval Service	1	0	Printer/ scanner	Y
No 4 W Bde	1	0	0	N
DFTC	1	0	0	N
Cathal Brugha	1	1	Printer/ scanner	Y
Wing St Bricin's	1	0	N	Y
Hospital St Bricin's	1	1	Printer/ scanner	Y
TOTAL	7	2	3	5 locations

Secondly, policy in relation to data backup must be implemented by Dental Officers to protect the data that they hold on behalf of the organization. Where necessary CIS will have to create password protected or encrypted server locations to protect confidential data. This matter will no doubt be of relevance to the wider Medical Corps. Where external backup has been provided the Dental Officer at that location should be instructed to backup on a cyclical basis and to remove backups from the surgery to a secure location. Appropriate anti-virus software, firewalls etc must be delivered by CIS to PCs not connected to the Intranet that are exposed to the threat of data corruption.

Thirdly, these issues highlight the dangers of compartmentalization in a distributed organization. Specialist digital x-ray equipment was purchased and CIS played a secondary role. CIS must be involved in all such projects to protect the organization's financial investment and data.

4.5.1.2 Personnel

Computer literate employees are needed to operate in an environment where records and management information are held electronically. Personnel were asked to give an indication of their familiarity with computers, ancillary equipment and software to gauge the capabilities of Dental Service personnel and to identify training requirements. The questionnaire was entirely subjective and is a blunt tool to identify areas of training need.

The assumption is made that personnel who consider themselves at Advanced or Proficient levels have a reasonable level of knowledge and do not require immediate training whereas personnel at Foundation or Intermediate levels, by contrast, should be selected for immediate training. Personnel also had the freedom to declare certain sections as irrelevant to daily work, by selecting the appropriate option. This may indicate resistance to change or the need for basic training. The results of the analysis are available for inspection in Appendix L

Table 17 below summarises attitudes to computers, file management and using the network.

Table 17: Reported proficiency using computers; file management and the network

	N/A (%)	Foundation (%)	Intermediate (%)	Proficient (%)	Advanced (%)
Computers and peripheral equipment	0	10	40	40	10
File management	0	20	30	20	30
Using the network	0	20	10	40	30

The questionnaires indicate that 50% of DFDS personnel regard themselves as being at a foundation or intermediate stage either in the use of computers or in file management whereas

70% feel that can use the network to a Proficient or Advanced level. Overall, 60% of the DFDS personnel interviewed felt at a foundation or intermediate stage when using some aspect of the current Information System despite the fact that 80% had been on at least one of many courses organized by the School of Administration. It is likely that these courses do not correspond with the tasks dentists and dental nurses are asked to do on the network. Task identification and training in these areas should be provided.

Personnel were asked to consider their proficiency using electronic diaries and word processing, spreadsheet, database and presentation software. This is summarized in Table 18 below.

Table 18: Reported proficiency using certain software applications

	N/A (%)	Foundation (%)	Intermediate (%)	Proficient (%)	Advanced (%)
Word processing	0	10	30	30	30
Spreadsheet	0	20	30	30	30
Database	10	60	10	10	10
Presentation	10	20	20	40	10
Electronic diaries	10	30	20	20	20

Personnel generally responded that they were familiar with word processing and presentation software and unfamiliar with database and spreadsheet software and electronic diaries. A high priority should be given to the use of electronic diaries in the Defence Forces as an aid in the management of equipment servicing, licence renewal, emergency drug replacement and other non-routine but essential matters. This will improve the management of these matters and remove reliance on the actions of a particular individual.

Further analysis of the distribution indicates that 90% of the Dental Officers regarded themselves as at 'Foundation' or 'Intermediate' in the use of spreadsheet software; 100% in the use of database software; 80% in the use of presentation software and 60% in the use of electronic diaries. Only 1 Dental Officer has completed the ECDL. The Dental Officers are the

managers of the service and are required to collect, analyse and present information to each other, to the Director of the Medical Corps, to representative organizations and to civilians, including purse-holders in the Department of Defence. A formal programme of instruction such as the ECDL is to be recommended for these personnel.

In relation to the use of e-mail and the Internet most personnel feel at a 'Proficient' or 'Advanced' level, with an age gap appearing in the expression of relative abilities. All personnel have an Intranet e-mail address and messages are copied and retained indefinitely by CIS. E-mail is a verifiable, reliable, quick means of communication that all personnel should be instructed in its use.

It is worth noting that the 2 personnel who completed the ECDL and continued to use their skills registered all their responses as 'Proficient' or 'Advanced', whereas the other respondent who completed the ECDL in dental school where, for instance, database and electronic diaries were not used, registered responses as 'Foundation' or 'Intermediate' in these areas. Logically it may be concluded that personnel should only be compelled to learn to use software that they will use in their daily tasks.

4.5.2 Information management

This section analyses the management of information at Directorate level, at dental surgeries in the Dental Service and by individuals working in these locations.

At Directorate level, there is a clear understanding of the need for a unique patient identifier, as provided by the Army number. The question of recycling of Army numbers used by the other ranks will have to be clarified. Recycling of numbers does not pose difficulties in a paper-based system where enough time elapses but will not work in an electronic record where records are kept indefinitely. Dental Officers are also clear that there is a unique identifier in the Defence Forces. However, the digital x-ray system in operation in the Western Brigade poses some questions in regard to application of this knowledge. X-rays are captured and stored in a stand-alone server that uses a proprietary identification number; the Army number is an identifier in the data set, as are other demographics. This may pose problems integrating this data into an EPR.

The Chief Dental Officer also acknowledged that there are no commitments to implement standards in relation to information management or to share data in the DFDS. Although deciding to implement standards can be made in principle by the CDO, there is an assumption that appropriate advice about the technical aspects will be provided by Communications and Information Systems (CIS) personnel. The CIS Corps will have to develop knowledge of medical/ dental informatics to inform similar decisions. The digital x-ray system in the Western Brigade is an example of the difficulties that may arise. Files are saved in a proprietary file format that is described by the vendors as being DICOM compatible rather than DICOM compliant and no DICOM conformance documentation is available. Although single images can be exported in jpeg format it is highly likely that there will be grave problems incorporating this data set into an EPR. The issue of DICOM compliance was not raised during the purchase of the system. Protocols to avoid similar problems need to be developed.

The Dental Officers at the five locations that have PCs were asked to what extent they use an IT system for administration. All are using the PMS in some form. Two of five locations also use word processing software to create, store and send referrals. One location sends referrals by e-mail. One location uses an electronic diary for personal and administrative engagements. In short, there is good acceptance of technology by Dental Officers. Suitable training will increase the acceptance and use of appropriate technologies.

Attitudes towards the in-house PMS and MIF are summarized in Table 19 below. In relation to the use of the PMS, 30% declared that they were at 'Foundation' or at 'Intermediate' levels of knowledge; further analysis revealed that all these personnel are Dental Officers, who manage the service but who do not use the PMS on a day to day basis because chairside PCs are not available. A dental nurse declared that the PMS was not applicable to her role, which on analysis reflects the lack of appropriate IT at that location.

Attitudes towards the MIF are less positive: 40% declared that they were at 'Foundation' or at 'Intermediate' levels of knowledge, including three Dental Officers; 20% - two dental nurses - declared that the MIF was not applicable to their role despite the fact that they are

directly employed to use the MIF to process AF207s. In one case PMS, IMS and MIF training had been provided to a dental nurse who was still not involved in the processing of AF207s.

Table 19: Reported proficiency using the PMS and the MIF

	N/A (%)	Foundation (%)	Intermediate (%)	Proficient (%)	Advanced (%)
PMS	10	20	10	30	30
MIF	20	20	20	20	20

The solution to these problems is to draw up a list of the courses required by occupation; to log the courses attended and to send personnel on appropriate courses. Tailored courses for dental personnel should be considered. Training all staff to the required standard will introduce redundancy and remove the dangers associated with over-reliance on key personnel, especially in an organization that allows promotion and movement from the clinical environment into administration roles outside the DFDS.

Personnel were also asked to specify their confidence identifying, obtaining, analysing and communicating information within the DFDS. A summary of the responses is shown in Table 20 below.

Table 20: Reported proficiency managing information

	N/A (%)	Foundation (%)	Intermediate (%)	Proficient (%)	Advanced (%)
Identifying	10	0	20	10	60
Obtaining	10	0	20	10	60
Analysing	10	0	20	20	50
Communicating	0	0	20	10	70

The vast bulk of DFDS personnel feel confident handling relevant information with 70% indicating an Advanced or Proficient level of knowledge. Role definition may help to address difficulties some personnel have in these areas.

The areas of clinical record keeping, clinical audit and evidence-based practice are increasingly examined in medical and dental practice. Attitudes towards these matters are summarized in Table 21 below.

Table 21: Reported proficiencies in record keeping, clinical audit and evidence-based practice

	N/A (%)	Foundation (%)	Intermediate (%)	Proficient (%)	Advanced (%)
Record keeping	0	0	20	40	40
Clinical audit	10	0	50	30	10
Evidence based practice	10	40	40	10	0

Good practice in record keeping allows retrospective audit that will inform future decisions through evaluation of success and failure. It may lead to the formulation of protocols or decision support to aid decision making. Clinical records are as a matter of course recorded on a daily basis in practice, however, no audits of practice have been carried out by Dental Service personnel to date and the service has not moved to evidence-based mode. This is reflected in the responses: 80% feel at a 'Proficient' or 'Advanced' level in record keeping; 40% in clinical audit and only 10% in evidence-based practice. Many helpful resources are now available on the web including the ADA's evidence-based dentistry website. Attendance at post-graduate education and meetings for clinical review should be organized to address these issues.

The final questions on information management addressed how well DF and national policies in relation to information handling are known by dental staff. Only one individual felt that the implications of these policies had been communicated effectively by the organization. 90% felt that their familiarity is at a 'Foundation' or 'Intermediate' level or that these policies are not relevant to their daily work. Legislation in relation to information use is supervised by the Data

Protection Commissioner. Civilian practices are required to register by law with the DPC and a data controller is required at each licensed site. The DF has registered DCoS(Sp) as the data controller but no specific mention of medical records has been made. Dental personnel do not know the identity of the data controller for the DF. Previous practice with paper records was to defer all such enquiries along the technical line of command with ultimate authority resting with DMed. The appropriate chain of command for data handling must now be defined.

4.5.3 Governance

In order to promote desirable behaviour, management must have policies and processes in place that will reduce risk to the organization. Governance encompasses physical security such as password changes; privacy and confidentiality; other legislative requirements and the ethics of information collection and use.

Physical security policies are dictated on the network by CIS policy. The system forces password changes and has appropriate user access controls. This is recognized at DFDS level and by location commanders – 100% reported that they have user access controls, lockable rooms and a system that forces password changes. However, elements of the system not controlled by CIS do not have as stringent security or access controls. For instance, referral letters are often stored on local hard drives in folders that are neither encrypted nor password protected. CIS can provide password protected folders on the server, for instance, to reduce the risk of data loss while preserving data security. From the point of view of governance, the CDO may direct that such folders are to be used as part of the management of this risk.

In terms of the understanding of individuals of the importance of physical security, 60% consider that their understanding of how to protect data against malicious damage or unauthorized access is at a 'Proficient' or 'Advanced' level while half consider that their knowledge of how to protect data against accidental damage is at a similar level. This reflects the clear direction given by CIS in relation to these matters.

One of the strengths of the DF is that there is a clearly defined hierarchical structure. The CDO and 6 of 7 location commanders reported that they could identify where matters of

data security should be reported. One DO was unsure whether data security matters should be reported to the CDO or to CIS personnel. Given the rarity of security issues, no location keeps a log of security issues. It is more practical to suggest that if incidents occur that they are recorded in the surgery safety book where other subjects such as radiation protection issues are also recorded. These issues can be covered by direction from the CDO.

Confidentiality and privacy are part of the business of working in a dental environment. Dentists are instructed in these matters in dental school and dental nurses are instructed during their training programme. There is no formal annual training program in the DFDS and no provision is available for updating personnel in relation to security, confidentiality, privacy and information sharing as is reflected in the responses of Dental Officers and the Chief Dental Officer. Informal induction training in these matters has, however, been given in 3 locations.

Since no research has been carried out in order to develop training programmes, it is not surprising that neither the Chief Dental Officer nor Dental Officers are certain who owns the data generated in the service. Most Dental Officers are of the opinion that the data is owned by the Minister for Defence. These matters will have to be clarified by the Legal Service.

No policy has been set in relation to informing patients of the proposed use of personal information. This reflects a considered view that patient information is only being used for clinical reasons.

Individuals working in the service have a very good understanding of privacy and confidentiality requirements as can be seen in the results shown in Table 22 below. In two specific areas (when data should be made anonymous and the changing needs of confidentiality in electronic records) personnel reported deficits in understanding. Since data can be more easily collated and transmitted in an EPR, these are topics that need to be addressed. In addition, most personnel declared that they had a very basic understanding of the implications of privacy legislation on data collection.

Table 22: Reported proficiency in the areas of privacy and confidentiality

	Foundation (%)	Intermediate (%)	Proficient (%)	Advanced (%)
Privacy	0	0	20	80
Anonymity of data	10	10	30	50
Patient consent to disclosure	0	0	40	60
Disclosing info to colleagues	0	0	30	70
Disclosing info to other agencies	0	0	30	70
Confidentiality & electronic records	0	30	20	50

Guidelines will have to be established by the Chief Dental Officer in relation to privacy and confidentiality. Induction training, handbooks, supporting documentation and annual training will have to be established to clarify these matters.

Knowledgeable consent allows dentists to proceed with treatment after the patient has made an informed choice regarding his options. It has evolved to reduce the risk of operator induced choice. No training is provided at service level in knowledgeable consent although two locations have provided local training. Standard consent forms are not available across the service. There has not been any training at service level, at locations or to individuals in relation to getting informed consent from children or minority groups.

The pressing need for such training is reflected in the opinion of one Dental Officer that patients surrender these rights upon joining the DF. The complexity of informed consent is also increasing with the increasingly heterogeneous population. A specific research group in this topic has been established by Prof Scully in the WHO Collaborating Centre for Oral Health, Disability and Culture in the Eastman Dental Institute, London (Available at: http://www.eastman.ucl.ac.uk/whocc.html Accessed 04 July 2009). The DFDS will have to investigate the changing requirements of informed consent and then establish training programmes to update dental personnel.

In summary, the dental module of the PMS is effectively unused because of the deficits in IT infrastructure. The CIS Corps must become suitably informed about dental informatics to give appropriate advice. Personnel must also be systematically trained in the use of appropriate software if they are to operate the PMS and MIF and then make the transition to an EPR. The service needs to be updated in the areas of consent, record keeping, clinical audit and evidenced-based dentistry so that appropriate clinical care may be provided to the highest standard.

5 Conclusions and future work

Dental paper records lack standardization but have common characteristics and are user friendly. Dental Electronic Patient Records (EPRs) also lack standardization but the evidence from the US is that EPRs are not user friendly and, in fact, interfere with workflow. There are also problems associated with inter-operability, especially when using dental x-rays. The American Dental Association has made considerable progress by issuing standards, recommendations and policy documents that address these problems. No standards have been adopted in Ireland in dental Information Systems and dental EPRs and no similar agency has acted to promulgate standards. In this vacuum vendors are providing a plethora of different products whose compatibility must be questioned.

This thesis has analysed the literature pertaining to dental information Systems and this has allowed certain conclusions to be made in relation to the development of the dental module of the Personnel Management System (PMS).

The research carried out in this thesis has analysed dental forensic charting. Liaison between the Communications and Information Systems (CIS) Corps and the Dental Service is necessary to determine the type of charting that will be recorded in the PMS. Commercial EPRs have been examined and weaknesses in their information models have been identified. Future work in the development of the PMS will aim to avoid these problems by correctly coding the appropriate information categories.

The research has also identified IT, information management and governance deficits that management in the Defence Forces needs to address. These findings are outlined below in the form of recommendations to the Chief Dental Officer.

Recommendation 1: Adopt the FDI system of tooth notation

The symbolic Zsigmondy system in current use is not easily adaptable for use in an EPR. The FDI system identifies teeth using two digits and preserves the association of tooth types found in the Zsigmondy system. Training in its use is required. Personnel should be instructed to collect tooth information clockwise from tooth 18 to tooth 48 to minimize transcription errors.

Recommendation 2: Use the PMS as a forensic record and an expanded function EPR

The dental module of the PMS should be expanded as a forensic and electronic patient record. The alternative is to cease development of the PMS and to reduce the charting codes to a generic format so that contact time with the PMS is at a minimum.

Recommendation 3: Formulate a plan with the CIS Corps to produce an EPR

A structured plan to develop an EPR should be formulated with the CIS Corps. There should be planned extensibility and modularized delivery.

Recommendation 4: Use a combination of charting codes in the forensic chart

A combination of tooth surface codes, codes for restorative materials and ancillary codes is an alternative to symbolic charting.

Recommendation 4a: adopt the tooth surface codes M, O, D, B, L

Recommendation 4b: adopt the restorative material codes outlined in Table 8 above

Recommendation 4c: adopt the ancillary codes outlined in Table 9 above

Recommendation 5: Rationalize the dental chart in the PMS to 3 lines

Combining the 'Missing' and 'Restored' lines concords with routine dental charting. The 'Tooth Wear and Trauma' line should be renamed to allow incorporation of additional data.

Recommendation 6: Incorporate x-rays or photographs into the forensic record

X-rays or photographs collect information useful in *post mortem* identification. This is of particular importance in the case of personnel without restorations.

Recommendation 7: Define the content of the EPR

The dental EPR should contain: progress notes; appropriate administration; forensic charting; x-ray information; photographs; a soft tissue record and periodontal charting.

Recommendation 8: Define the information categories and sub-categories

The following information categories should be incorporated into the EPR: Demographic; medical history; reason for attendance and problem list; social history and dental history; clinical exam; radiographic exam; dental diagnoses; treatment plan; procedure codes and progress notes. Further work will have to be completed to define the exact coding of these categories.

Recommendation 9: Adopt DICOM and other universal standards

Only DICOM compliant x-ray systems with DICOM conformance statements should be purchased. Where other standards can be used they should be adopted.

Recommendation 10: Develop the capacity of the CIS Corps to provide competent advice

The CIS Corps liaison Officer should be advised about the standards particular to healthcare and the known problems of interoperability so that corporate knowledge can be developed.

Recommendation 11: Digitize the administration associated with the DFDS

Digitizing the documents associated with the business of dentistry, as outlined in Table 12 above and altering associated workflow may offer significant time savings.

Recommendation 12: Inform CIS of deficits in IT infrastructure

The IT deficits have been outlined in Table 16 above. Other infrastructure such as appropriate cabling and access points must also be provided.

Recommendation 13: Identify software courses appropriate to Dental Service roles

Each role in the service should be associated with a specific set of competencies. The ECDL should be completed by all personnel as should training in the use of the PMS, the MIF and electronic diaries.

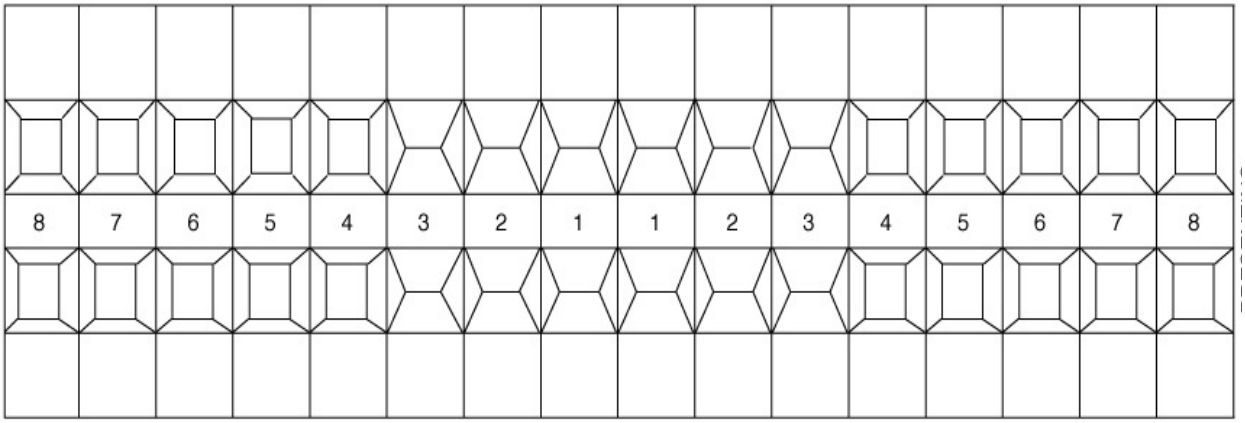
Recommendation 14: Develop an information governance policy

The Chief Dental Officer should liaise with the CIS Corps to develop a governance policy for the Dental Service. Of particular importance are issues relating to security and compliance with legislation.

6 Appendices

Appendix A: Forensic charting questionnaire

Dental chart issued to personnel:



Charting requested:

DOP	OP	Denture	MO	O	Missing	Deciduous	Bridge	Bridge	Bridge	Post	RCT	MOD	DO	Anomaly	Temp
18	17	16	15	14	13	12	11	21	22	23	24	25	26	27	28
48	47	46	45	44	43	42	41	31	32	33	34	35	36	37	38
Unerupted	Fissure sealant	Pin	Implant	MODL	Movement	Supernumerary	Veneer	Incisal	Crown	Retained root	MO inlay	OB	Sound	MOB	Part erupted

Appendix B: Forensic charting by DFDS personnel

Procedure /Individual	D1	D2	N1[5]	D3	N2	D4	N3	D5	N4	N5
Sound	-	-	-	-	(s) sd	-	-	-	-	-
Absent	(s)	(s)	(s)	(s)	(s)	(s)	(s)	(s)	(s)	(s)
Root	+	(s) (t)	(s)	(s) (t)	RT	(s)	(t)	RR	(s)	(s), RT
Crown	Cr, PJC, BCR, FGC	Cr	Cr	Cr, PJC, BCR, FGC	Cr, PJC, BCR, FGC	Crown (t)	Cr, PJC, FGC	PJC, FGC, PFM	PJC, PFM, FGC, Cr, C	BC, PJC, FJC, Cr
Veneer	CV, PV	Ven	V	(t)	V	Veneer (t)	VNR	Veneer (t)	Veneer (t)	Veneer (t)
Bridge	CR=CR (s)	Br (s)	Br	Br (s)	Br	Bridge (t)	Br	Br	Br, Bp	Br, Bp
Denture	P/	A	A	P	-	-	P	-	-	Dent (t)
Implant	Implant (t)	Implant (t)	Implant (t)	Implant (t)	Imp (t)	Implant (t)	Imp	Implant (t)	Implant (t)	Implant (t)
Inlay	Inlay (t)	Inlay (t)	-	Inlay (t)	Inlay (t)	Inlay (t)	-	Inlay (t)	Inlay (t)	Inlay (t)
F/S	F/S	FS	F	FS	FS	Fissure seal (t)	FS	F/S	FS	FS
Temp	Td	(s)	-	TF	TF	(s)	-	T	(s)	Temp (t)
Pin	-	-	-	Pin	Pin	-	-	Pin	Pin	-
Post	PCR[1]	-	-	PCR[1]	PCR[1]	-	-	-	-	-
RCT	RT[2], RCT[3]	RT[2]	RT[2]	RCT'd[2]	RCT[2]	RCT[2]	RCT[2]	RCT[2]	RCT[2]	RCT[2]
Movement	(s)	(s)	(s)	(s)	(s)	(s)	(s)	(s)	(s)	(s)
P/E	PE	PE	PE	PE	PE	PE	PE	P/E	PE	PE
U/E	U	U	UE	UE	U	UE	UE	U/E	UE	UE
Supernumerary	(t)	Sup (t)	Sup (t)	(t)	Sup (t)	(t)	(t)	(t)	(s)	S
Deciduous	a[4]	A	A	a	A	a	A	a	A	A
Anomaly	(t)	(t)	-	(t)	(t)	(t)	(t)	(t)	(t)	(t)
Caries	(s)	(s)	(s)	(s)	(s)	(s)	(s)	(s)	(s)	(s)
SURFACES										
M	M (s)	M (s)	M (s)	M (s)	M (s)	M (s)	M (s)	M (s)	M (s)	M (s)
O	O (s)	O (s)	O (s)	O (s)	O (s)	O (s)	O (s)	O (s)	O (s)	O (s)
D	D (s)	D (s)	D (s)	D (s)	D (s)	D (s)	D (s)	D (s)	D (s)	D (s)
B	B (s)	B (s)	B (s)	-	B (s)	B (s)	B (s)	B (s)	B (s)	B (s)
L	L (s)	L (s)	L (s)	L (s)	L (s)	L (s)	L (s)	L (s)	L (s)	L (s)
I	I (s)	I (s)	I (s)	I (s)	I (s)	I (s)	I (s)	I (s)	I (s)	I (s)

MATERIALS										
Porcelain	P	-	-	P	P	-	-	-		
Composite	C	-	-	-	-	-	-	-		
Amalgam	-	-	-	-	-	-	-	-		
Gold	-	-	-	-	-	-	-	-		
GI	-	-	-	-	-	-	-	-		
Non-precious metal										
Restorations	(s)	(s)	(s)	(s)	(s)	(s)	(s)	(s)	(s)	(s)

1 if with crown
2 if RCT'd
3 RCT needed
4 tooth present ticked
5 significant charting errors recorded

(s) symbolic
(t) text

Appendix C: Forensic charting in EPRs

	PMS	WINID	IDIS	DAVID	TAB Dental	Exact	Panara	Bridges
Sound	ST, SU, P	V	V	Sound (s)				(s)
Absent	E, M, MC	X, J	U, X, J, ?	Missing, (s) socket	(s)	Miss (s)	(s)	(s)
Root				Root (s)	RetRoot (s)	ZRet (s)	(s)	(s)
Crown	CRW	C	C	Crown (s)	GC, PC, BC (s)	CFG, CPB,CPJ (s)	C	(s)
Veneer					VN	IVV (s)	(s)	(s)
Bridge	BR	P	P	Bridge (s)	GR, PR, BR, GP, PP, BP (s)	BMF, BMW, BPBF (s)	R, P	(s)
Denture		T	T, F	Dentures (s)	AT	DA, DC (s)	(s)	(s)
Implant	OII		W		Implant (s)	CIMP (s)	I	(s)
Inlay	ICR					IVG, IVC, IVP (s)	-	-
F/S	FS					FS (s)	-	F/S (s)
Temp		Z	K			-	-	-
Pin					Pin (s)	-	-	-
Post			Q		(s)	CPOST	-	-
RCT	RFT	R	R			RCT	-	(s)
Movement	LD PD R				(s)	(s)	(s)	(s)
P/E	PE				PE	ZPer	PE	(s)
U/E	U	U		Unerupted (s)	UE	ZUNE	UE	(s)
Supernumerary			Y			Super	(s)	
Deciduous		B				(s)	(s)	(s)
Anomaly	-	A	A		-	NOTETS	-	-
Caries	Coded	-	Z	Damaged (s)	D	(s)	(s)	(s)

SURFACES								
M	M	M	M	(s)	(s)	(s)	(s)	(s)
O	O	O	O	(s)	(s)	(s)	(s)	(s)
D	D	D	D	(s)	(s)	(s)	(s)	(s)
B	*	F	B	(s)	(s)	(s)	(s)	(s)
L	*	L	L	(s)	(s)	(s)	(s)	(s)
I		I	O	(s)	(s)	(s)	(s)	(s)
MATERIALS								
Porcelain		H	H			P	-	-
Composite		E	E			C	-	-
Amalgam		S	S			AM	-	-
Gold		G	G			G	-	-
Glass-Ionomer			E			GI	-	-
Non-precious		N	N					
Restorations	coded	coded	coded	(s)	(s)	coded (s)	(s)	(s)

(s) symbolic
(t) text

Appendix D: Baseline Dental Record

BDR fields and their frequency on paper and CPRs

Data Element		Category
CATEGORY 1: CHIEF COMPLAINT		
Chief oral complaint	text	1
Do you have any discomfort/problems?	yes/no	1
History of chief complaint	text	1
Other primary reason		1
Other reasons for seeing dentist		1
Primary reason for appointment		1
CATEGORY 2: MEDICATION HISTORY		
Anticoagulants	yes/no	2
Aspirin	yes/no	2
Cortisone	yes/no	2
Fen-Phen/Redux	yes/no	2
List any prescribed (or OTC) drugs.	text	2
Sedatives	yes/no	2
Steroids	yes/no	2
Tranquilizers	yes/no	2
CATEGORY 3: MEDICAL HISTORY		
CATEGORY 3.1: PAST AND PRESENT ILLNESSES		
Allergies	yes/no	3.1
Anaphylaxis	yes/no	3.1
Anemia or sickle cell	yes/no	3.1
Angina	yes/no	3.1
Arthritis	yes/no	3.1
Artificial joints	yes/no	3.1
Asthma	yes/no	3.1
Atopic (Allergy Prone)	yes/no	3.1
Back problems	yes/no	3.1
Bled excessively after being cut or injured	yes/no	3.1
Blood disorder such as anemia, leukemia, etc	yes/no	3.1
Blood transfusions	yes/no	3.1
Bruising (frequent)	yes/no	3.1
Cancer or Tumor	yes/no	3.1
Chemical dependency	yes/no	3.1
Chemotherapy/Radiotherapy	yes/no	3.1
Chest pain	yes/no	3.1
Childhood diseases	yes/no	3.1
Chronic fatigue syndrome	yes/no	3.1
Circulatory problems	yes/no	3.1
Common Cold	yes/no	3.1
Congenital heart defect/problem	yes/no	3.1

Cortisone treatments	yes/no	3.1
Cough (persistent)	yes/no	3.1
Cough up blood	yes/no	3.1
Diabetes	yes/no	3.1
Difficulty breathing	yes/no	3.1
Drug or alcohol abuse	yes/no	3.1
Eating disorders	yes/no	3.1
Emphysema or Bronchitis	yes/no	3.1
Epilepsy/or seizures	yes/no	3.1
Eye disorder	yes/no	3.1
Fainting	yes/no	3.1
Food Allergies	yes/no	3.1
Glaucoma	yes/no	3.1
Hay fever	yes/no	3.1
Headaches or migraine	yes/no	3.1
Heart: artificial valves	yes/no	3.1
Heart: attack or stroke	yes/no	3.1
Heart: defect or heart murmur	yes/no	3.1
Heart: disease, attack or angina	yes/no	3.1
Heart: irregular heartbeat	yes/no	3.1
Heart: surgery or pacemaker	yes/no	3.1
Hemophilia or abnormal bleeding	yes/no	3.1
Hemorrhage	yes/no	3.1
Hepatitis, jaundice or liver disease	yes/no	3.1
Herpes	yes/no	3.1
High or low blood pressure	yes/no	3.1
HIV+/AIDS	yes/no	3.1
Hives or skin rash	yes/no	3.1
Hypoglycemia	yes/no	3.1
Infarct or thrombosis	yes/no	3.1
Jaw pain	yes/no	3.1
Kidney disease or malfunction	yes/no	3.1
Lung disease or breathing problems	yes/no	3.1
Material allergies (latex, wool, metal, chemicals)	yes/no	3.1
Mental diseases	yes/no	3.1
Mitral valve prolapse	yes/no	3.1
Mononucleosis	yes/no	3.1
Neurological problems	yes/no	3.1
Other	yes/no	3.1
Pacemaker or artificial heart valve	yes/no	3.1
Pneumonia	yes/no	3.1
Polio	yes/no	3.1
Prosthetic valves or joints	yes/no	3.1
Psychiatric care	yes/no	3.1
Rapid weight gain/loss	yes/no	3.1
Rheumatic fever or heart murmur	yes/no	3.1
Scarlet fever	yes/no	3.1
Serious illness or major surgery	yes/no	3.1

Shingles	yes/no	3.1
Shortness of breath	yes/no	3.1
Sinusitis or sinus problems	yes/no	3.1
Skin rash	yes/no	3.1
Sore throat	yes/no	3.1
Spina bifida	yes/no	3.1
Stomach problems or intestinal disease	yes/no	3.1
Stroke	yes/no	3.1
Surgical implant	yes/no	3.1
Swelling of feet or ankles or hands	yes/no	3.1
Syphilis	yes/no	3.1
Thyroid disease or malfunction	yes/no	3.1
Tobacco habit	yes/no	3.1
Tonsillitis	yes/no	3.1
Trauma to head, neck or jaw	yes/no	3.1
Tuberculosis or PPD+	yes/no	3.1
Ulcers or Colitis	yes/no	3.1
Ulcers Oral (cold sores, fever blisters)	yes/no	3.1
Venereal disease	yes/no	3.1
Alzheimer's		3.1
Artificial heart		3.1
Convulsions		3.1
Cosmetic surgery		3.1
Dizziness		3.1
Easily winded		3.1
Excessive thirst		3.1
Frequent diarrhea		3.1
Genital herpes		3.1
Hepatitis A		3.1
Hepatitis B		3.1
Parathyroid disease		3.1
Pneumocys		3.1
Recent weight loss		3.1
Rheumatism		3.1
CATEGORY 3.2: HEALTH HISTORY		
Are you in good health?	yes/no	3.2
Change in health history	text	3.2
Contact lenses	yes/no	3.2
Hospitalizations	text	3.2
Last physical	text (date)	3.2
Oral hygiene	multiple	3.2
Weight loss	yes/no	3.2
Do you need to pre-medicate?		3.2
Medication for pre-med		3.2
Special diet		3.2
CATEGORY 3.3: ALLERGIES		

Any metals	yes/no	3.3
Aspirin	yes/no	3.3
Barbiturates	yes/no	3.3
Bleach	yes/no	3.3
Codeine	yes/no	3.3
Drugs	yes/no	3.3
Erythromycin	yes/no	3.3
Iodine	yes/no	3.3
Latex (balloons, gloves, etc)	yes/no	3.3
Local anesthetic	yes/no	3.3
Nitrous oxide	yes/no	3.3
Other	text	3.3
Penicillin	yes/no	3.3
Sulfa	yes/no	3.3
Acrylic		3.3
Jewelry		3.3
Tetracycline		3.3
CATEGORY 3.4: WOMEN ONLY		
Abortions	text	3.4
Are you pregnant?	yes/no	3.4
Birth control pills	yes/no	3.4
Breast feeding	yes/no	3.4
Date of delivery	text	3.4
CATEGORY 3.5: VITAL SIGNS		
Blood pressure	text	3.5
Pulse rate	integer	3.5
Pulse rhythm	check, rate	3.5
Temperature	text	3.5
Weight/Height	text	3.5
CATEGORY 4: DENTAL/ SOCIAL HISTORY		
CATEGORY 4.1: DENTAL HISTORY		
Any previous major dental treatment/when	text	4.1
Are any teeth loose?	yes/no	4.1
Are you aware of any problem?	text	4.1
Are you happy the way your teeth/smile/replacement look?	yes/no	4.1
Are you satisfied with your present dentures?	yes/no	4.1
Are your teeth sensitive to cold/hot/sweets?	yes/no	4.1
Bad taste/bad breath	yes/no	4.1
Burning lips or tongue	yes/no	4.1
Caries susceptibility	yes/no	4.1
Changes in your occlusion	yes/no	4.1
Cheek biting/lip biting	yes/no	4.1
Chewing	yes/no	4.1
Comments	text	4.1

Date of placement	text	4.1
Date of your last dental visit/exam	date	4.1
Dental history summary box	text	4.1
Dental history update	text	4.1
Dental hygiene (excellent to poor)	check	4.1
Describe your dental health at present	check	4.1
Did you ever wear braces/ortho?	yes/no	4.1
Disclosing tablets	yes/no	4.1
Do you floss your teeth/type floss?	text	4.1
Do you get nervous before dental treatment?	yes/no	4.1
Do you have discolored teeth that bother you?	text	4.1
Do you like to know about permanent replacements?	yes/no	4.1
Do you wear dentures or partials?	yes/no	4.1
Do your gums bleed, feel tender, or irritated?	yes/no	4.1
Does food wedge between certain teeth?	yes/no	4.1
Fluoride rinse or supplements	yes/no	4.1
For how long did your gums bleed?	text	4.1
Hardness (toothbrush)	text	4.1
Have there been replaced extracted teeth?	yes/no	4.1
Have you ever had a root canal?	yes/no	4.1
Have you ever had difficult extractions?	yes/no	4.1
Have you ever had gum treatment?	yes/no	4.1
Have you ever had prolonged bleeding after extractions?	yes/no	4.1
Have you experience any growths or sore spots in your mouth?	yes/no	4.1
Have you had any extractions?	yes/no	4.1
Have you lost any teeth/why?	text	4.1
Have you made regular visits?	yes/no	4.1
Have you received any hygiene instructions?	yes/no	4.1
Have you worn any dental appliances?	yes/no	4.1
Have your front teeth separated?	yes/no	4.1
Headaches	yes/no	4.1
How many times a day do you brush/floss?	text	4.1
How often did you visit the dentist before then?	yes/no	4.1
If not, why?	text	4.1
If you could change anything about your smile …	text	4.1
Interdental stimulant	text	4.1
Is your drinking water fluoridated?	yes/no	4.1
Is your present dental health poor?	yes/no	4.1
Last cleaning	text	4.1
Mouth breathing	yes/no	4.1
Oral water spray	yes/no	4.1
Previous dentist name/location	text	4.1
Problems/unfavorable previous dental treatment	yes/no	4.1
Rank reasons keeping you from getting dental treatment	text	4.1
Sounds around your ears	yes/no	4.1
Swelling or lumps in mouth	yes/no	4.1
Teeth clenching or grinding/when	text	4.1
Teeth sensitive upon biting	yes/no	4.1

Toothbrush brand	text	4.1
Toothpaste brand	text	4.1
Type of dental experience	yes/no	4.1
Type of tooth brush soft or hard	check	4.1
Ulcers/blisters on lips or tongue	yes/no	4.1
Unable to open/close mouth	yes/no	4.1
What is your most important dental health concern?	text	4.1
What was done then?	text	
Emotional motivations/ concerns		4.1
Mouthwash		4.1
Percieved level of aesthetics		4.1
Percieved level of function		4.1
CATEGORY 4.2: SOCIAL HISTORY		
Alcohol	yes/no	4.2
Alcoholism	yes/no	4.2
Controlled substances	yes/no	4.2
How much/how many years?	text	4.2
Smoking/tobacco use	yes/no	4.2
Talk with Dr. privately about any problem	yes/no	4.2
CATEGORY 4.3: PAIN		
Does your jaw ever click or cause pain?	yes/no	4.3
Pain around ear	yes/no	4.3
Do you feel pain in any of your teeth?	text	4.3
Mucosal		4.3
Myofacial		4.3
CATEGORY 6: INTRAORAL EXAMINATION		
Abscesses	text	6
Alveolar ridge maxilla/mand.	text	6
Buccal mucosa	text	6
Color	text	6
Condition of periodontium	text	6
Exudate	text	6
Floor of mouth	text	6
Frenum	text	6
Gingiva	text	6
Hard palate	text	6
Labial mucosa	text	6
Lips	text	6
Oral mucosa	text	6
Other abnormalities	text	6
Palate	text	6
Papillae	text	6
Pathological findings	text	6
Pharynx	text	6
Pillars and trigone	text	6

Recession	text	6
Saliva	text	6
Salivary gland	text	6
Soft palate	text	6
Tongue	text	6
Tonsil area	text	6
Vestibules	text	6
Biopsy		6
Comments		6
Edentulous ridge		6
Retro molar		6
Salivary ducts		6
Tori		6
Tuberosity		6
CATEGORY 7: EXTRAORAL EXAM		
Eyes	text	7
Facial profile	text	7
Hands	text	7
Head	check	7
Lymph nodes	text/ check	7
Neck	check	7
Skin	text	7
Ext head/ neck		7
Facial tissue		7
Skeletal aberration		7
CATEGORY 8: TMJ AND OCCLUSION		
CATEGORY 8.1: TMJ		
Deviation on closing	int	8.1
Difficulty chewing	yes/no	8.1
Difficulty opening/closing	yes/no	8.1
Jaw sounds/pain	yes/no	8.1
Maximum opening	int	8.1
Muscles	text	8.1
Previous TMJ therapy	yes/no	8.1
Requires further TMJ evaluation	yes/no	8.1
Tenderness to palpation	right/left	8.1
TMJ evaluation	text	8.1
CATEGORY 8.2; OCCLUSION		
Abrasions	text	8.2
Anterior crowding	text	8.2
Bleeding	text	8.2
Calculus	yes/no/m ultiple	8.2
Condition of teeth	text	8.2
Condition or present dentistry	text	8.2

Contact points	text	8.2
Crossbite	text	8.2
Eruption pattern	text	8.2
Food retention	text	8.2
Mid-line	text	8.2
Open bite	text	8.2
Other	text	8.2
Overhangs	text	8.2
Over-jet	text	8.2
Plaque	text	8.2
Recession	text	8.2
Space management	text	8.2
Stains	text	8.2
Supernumerary	text	8.2
Wear	text	8.2
CATEGORY 8.3: PARAFUNCTION		
Nail biting, cheek biting, lip biting	text	8.3
CATEGORY 9: RADIOGRAPHIC		
CATEGORY 9.1: RADIOGRAPHIC HISTORY		
Cone length	text	9.1
Date	date	9.1
KVP	text	9.1
Last full mouth x-rays	text	9.1
mA	text	9.1
Number of films	text	9.1
Other factors	text	9.1
Seconds	text	9.1
Type	text	9.1
Were X-rays taken of all teeth at that time/when?	yes/no	9.1
CATEGORY 9.2: RADIOGRAPHIC FINDINGS		
Bone level/furcation	text	9.2
Caries, restored	check	9.2
Evaluation periapical and periodontal signs	text	9.2
Other findings	text	9.2
Pulp cavity	text	9.2
Tooth conditions	text	9.2
Tooth support	graphic	9.2
X-ray findings	text	9.2
CATEGORY 10: PHYSICIAN INFORMATION		
Are you under the care of a physician?	yes/no	10
Explanation of medical care	text	10
Physician's E-mail	text	10
Physician's name	text	10
Physician's name, address, phone number	text	10

Since when?	date	10
CATEGORY 11: ALERT/ SUMMARY BOX		
Medical alerts	text	11
Medical history summary box	text	11
CATEGORY 12; MEDICAL HISTORY UPDATE		
Current medications	text	12
Date	date	12
Date of initial medical history	date	12
Health changes	text	12
Last exam	date	12
Physician name & phone number	text	12
CATEGORY 13: CONSULTATION		
Date	date	13
Findings/recommendations	text	13
Request	text	13
Signature	text	13
Specialist/name	text	13
Time	time	13
To/from	text	13
Address		13
Due back		13
Returned		13
CATEGORY 14; SYSTEMIC DIAGNOSES		
ASA Classification	text	14
Differential diagnosis of findings	text	14
Presenting Conditions	text	14
CATEGORY 15: DENTAL DIAGNOSES		
Abnormalities	text	15
Advanced periodontitis	check	15
Gingivitis	check	15
Moderate periodontitis	check	15
Oral/dental diagnosis	text	15
Pathological findings	text	15
Periodontitis	check	15
Periodontitis Type: I, II, III, IV, Advanced	check	15
Presenting conditions/apparent dental problem	text	15
ANUG		15
Early onset		15
Systemic associated		15
CATEGORY 16: PROBLEM LIST		
Comments	text	16
Date	date	16

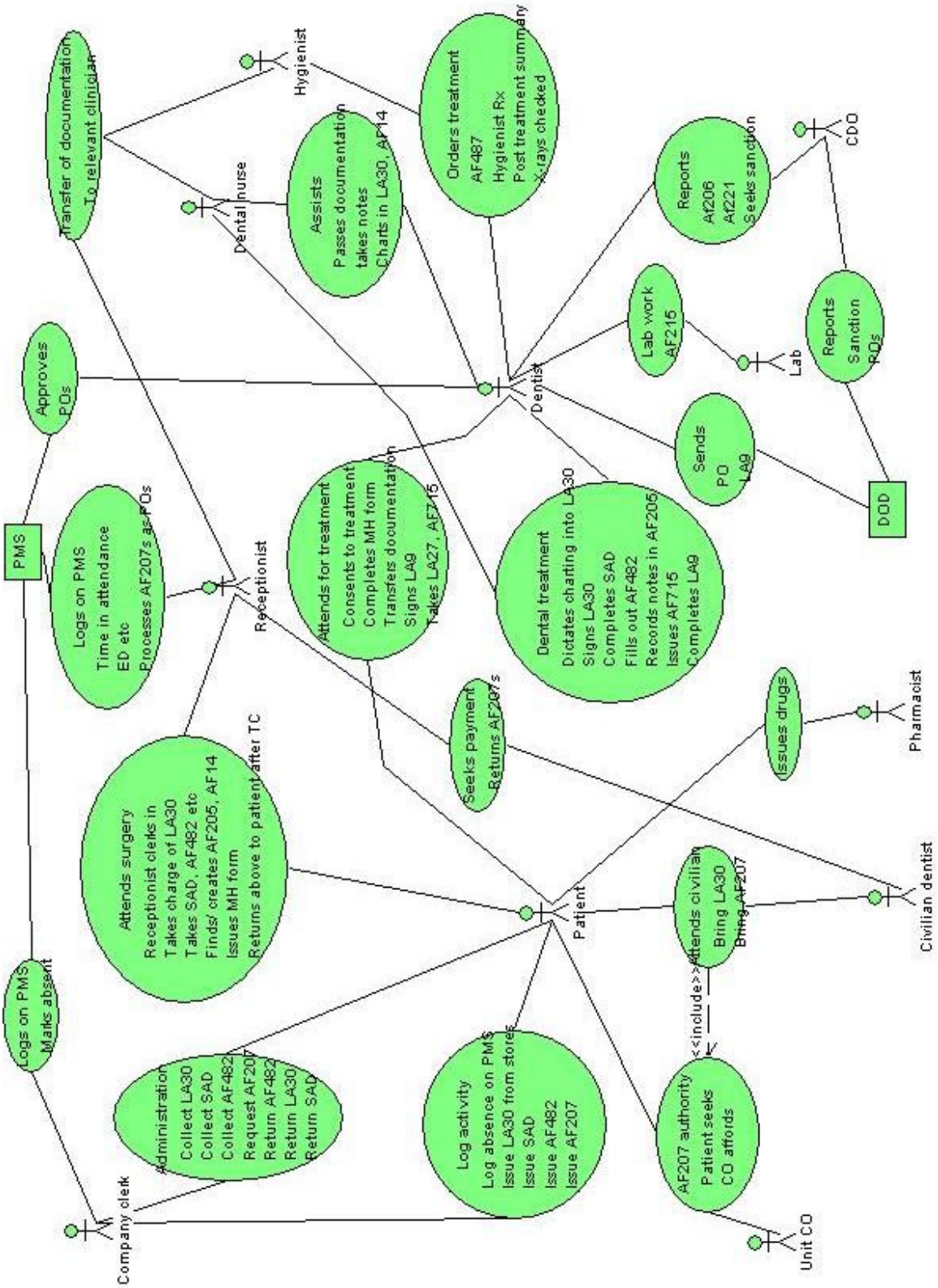
Date problem solved	date	16
Problem	text	16
Problem number	integer	16
Tooth number	text	16
Treatment	text	16
CATEGORY 17: PROGNOSIS/ RISK ASSESSMENT		
Etiology	text	17
Prognosis	text	17
Risk assessment	text	17
CATEGORY 18: TREATMENT PLAN		
ADA/service code	text	18
Alternate treatment	text	18
Appointment date/time	text	18
Appointment number	numeric	18
Date	date	18
Date completed	date	18
Date diagnosed	date	18
Date procedure was initiated	date	18
Days Between appointments	numeric	18
Dr. No.	numeric	18
Dr./Assistant initials	text	18
Planned services not completed	text	18
Problem	text	18
Problem number	numeric	18
Proposed treatment	text	18
Time needed	text	18
Tooth number/surface	numeric	18
Units (T/S)	text	18
Insurance amount		18
Patient (€)		18
Group		18
*(primary, secondary, estimate)		18
Status (proposed, accepted, completed)		18
Discount		18
# (phase of service)		18
CATEGORY 19: PROGRESS NOTES		
ADA/Service code	text	19
Anesthetic given	text	19
Asst. initials	text	19
Date	date	19
Dr./Asst.	text	19
Problem number	integer	19
Recall date	date	19
Tooth number and surface	text	19
Treatment	text	19

Date entered		19
Type (completed, existing, perio exam, panex etc)		19
CATEGORY 20: PRESCRIPTIONS		
Prescription	text	20
Address		20
Date		20
Description		20
Dispense as written		20
DOB		20
Doctor		20
Drug name		20
Generic permitted		20
Label		20
Patient instructions		20
Patient name		20
Quantity		20
Refill		20
Sig		20

Appendix E: Forms in use in the Dental Service

Document number	Purpose
AF14	Individual charting record
AF205	Dental patient record card
AF206	Dental Officer day book
AF207	Civilian dentist authorization
AF215	Dental laboratory prescription
AF221	Weekly Dental Officer returns
AF335	Charting report
AF487	X-ray/ imaging prescription
AF715	Relief from hospital charges
Hygienist referral	Hygienist treatment plan
Hygienist return	Post treatment summary
LA27	Drug prescription
LA30	Personal medical administration record
LA9	Co-payments authorization
Medical history	Medical history
SAD	Administration for overseas appointment
Sanction	Authorizes financial expenditure

Appendix F: Use case for DFDS

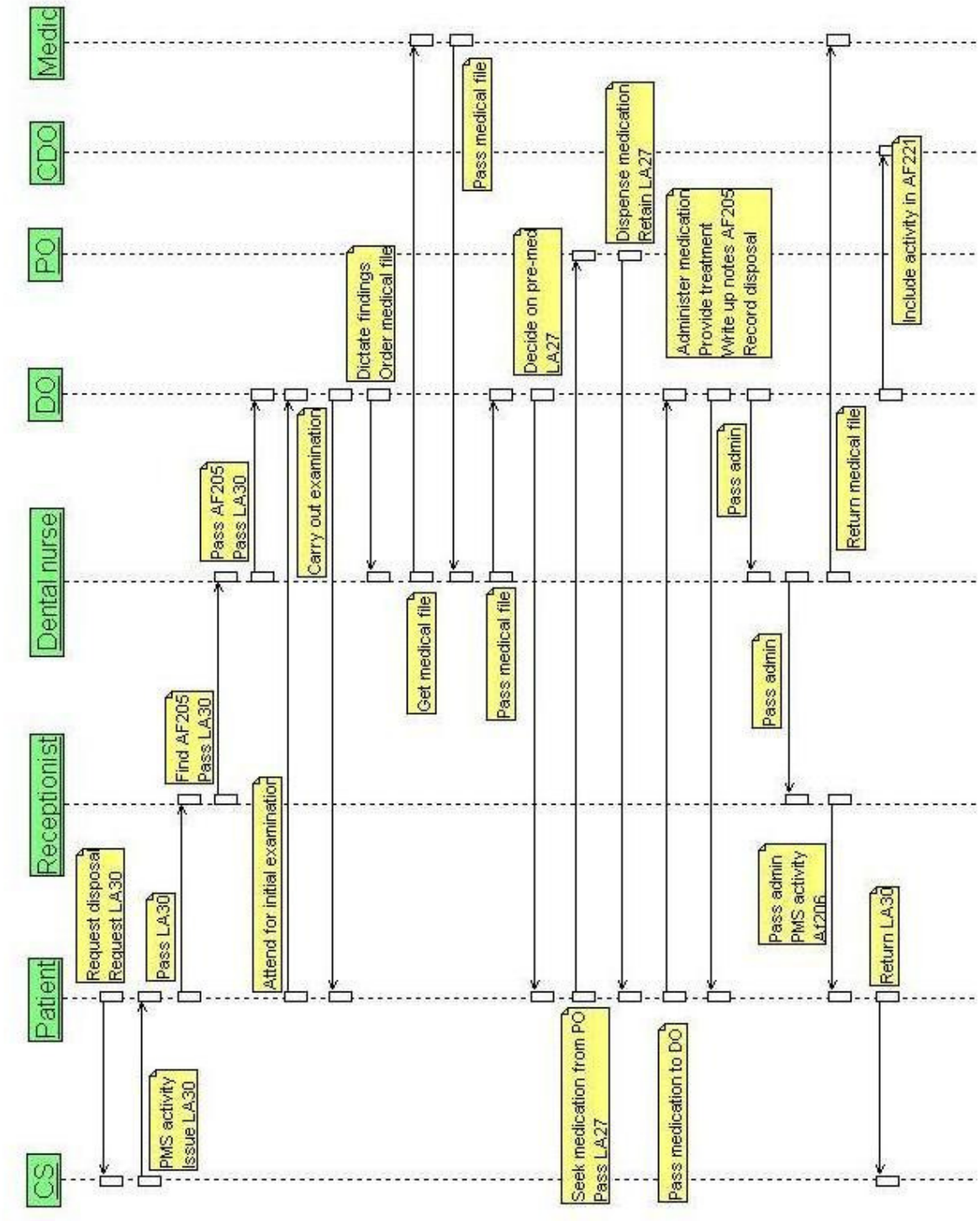


Appendix G: Case study - treating a medically high-risk patient

Actor	Location	Intent/ Strategy	Action	Af/	Breakdowns
Patient	Coy Office	Attend Coy Office for permission to see dentist	Go sick on PMS	PMS	Coy Office closed
			Draw LA30	LA30	Missing LA30
	Dental Office	Attend for treatment	Go on dental sick parade		
Receptionist	Dental	Clerking duties	Collect RFA		
			Issue MH form	Med Hx	Forget to issue
			Obtain patient record card	Af205	Missing, duplicate card
			Collect LA30	LA30	No LA30
			Transfer admin to clinic	Af205, LA30, Med	
Dental	Dental	Collect patient			
DO	Dental Office	Med hx review	Check medical hx	Med Hx form	Incomplete med hx
			Identify medical hx complication	Med Hx form	Details held in patient med file
			Order nurse to get patient medical file	Medical file	
Dental nurse	OPD	Collect patient medical file	Nurse goes to OPD to get patient file	Medical file	Patient file in another
					MO has file
					Patient file missing
	Dental office	Give patient file to DO	Give patient file to DO	Medical file	
DO	Dental Office	Patient examination	Carry out clinical examination	Af205	
		Decision re pre-medication	Review medical file and decide on pre-medication	Medical file	Incomplete file etc
			Write prescription	LA27	Errors in prescription
Patient	Pharmacy (Mil)	Collect pre-medication	Hand prescription to pharmacist	LA27	

PO	Pharmacy (Mil)	Dispense drugs	Examine prescription	LA27	
			Check for drug interactions/ allergy		
			Issue drugs		
			Provide patient instruction		
Patient	Dental office	Return with pre-medication	Give pre-med to dental staff		
DO	Dental office	Supervise/ administer pre-medication	Supervise/ administer pre-medication		
		Carry out dental treatment	Extract tooth	Af205	
			Give post-op instructions	Af205	
			Clinical disposal on LA30	LA30	No LA30
Receptionist	Dental Office	Complete clerking	Mark disposal on PMS	PMS	
			Re-file records	Af205 & med Hx	Filing errors
			Enter details in AF206		
Dental nurse	OPD	Return patient file to OPD		Medical file	
Dentist	Dental Office	Collate information	Compile weekly return	Af221	AF206 incomplete etc
Patient	Company Office	Complete admin	Return LA30 to Coy Office	LA30	
			Inform C/S re clinical disposal	PMS	

Appendix H: Sequence diagram - treating a medically high-risk patient



Appendix I: Individual audit questionnaire

Information technology

What is your proficiency using:

Q1 Personal computers and peripheral equipment

- Foundation •Intermediate •Proficient •Advanced •N/A

Q2 File management

- Foundation •Intermediate •Proficient •Advanced •N/A

Q3 Using the network

- Foundation •Intermediate •Proficient •Advanced •N/A

Q4 Using word processing software

- Foundation •Intermediate •Proficient •Advanced •N/A

Q5 Using spreadsheet software

- Foundation •Intermediate •Proficient •Advanced •N/A

Q6 Using database software

- Foundation •Intermediate •Proficient •Advanced •N/A

Q7 Using presentation software

- Foundation •Intermediate •Proficient •Advanced •N/A

Q8 Using e-mail

- Foundation •Intermediate •Proficient •Advanced •N/A

Q9 Using the Internet

- Foundation •Intermediate •Proficient •Advanced •N/A

Q10 Using electronic diaries

- Foundation •Intermediate •Proficient •Advanced •N/A

Q11 Have you completed the ECDL?

Q12 Any other IT courses?

Information management

How confident are you in the following areas:

Q13 Dental module PMS

- Foundation •Intermediate •Proficient •Advanced •N/A

Q14 MIF

- Foundation •Intermediate •Proficient •Advanced •N/A

Q15 Identifying information need

- Foundation •Intermediate •Proficient •Advanced •N/A

Q16 Obtaining information

- Foundation •Intermediate •Proficient •Advanced •N/A

Q17 Analysing and interpreting information

- Foundation •Intermediate •Proficient •Advanced •N/A

Q18 Communicating information

- Foundation •Intermediate •Proficient •Advanced •N/A

Q19 Clinical record keeping

- Foundation •Intermediate •Proficient •Advanced •N/A

Q20 Clinical audit

- Foundation •Intermediate •Proficient •Advanced •N/A

Q21 Evidence based practice

- Foundation •Intermediate •Proficient •Advanced •N/A

Q22 DF information strategy

- Foundation •Intermediate •Proficient •Advanced •N/A

Q23 National information strategies

- Foundation •Intermediate •Proficient •Advanced •N/A

Governance

How well do you understand:

Q24 The underlying ethical procedures behind information collection/ use

- Foundation •Intermediate •Proficient •Advanced •N/A

Q25 Consent involving children

- Foundation •Intermediate •Proficient •Advanced •N/A

Q26 Consent to use information for research

- Foundation •Intermediate •Proficient •Advanced •N/A

Q27 Privacy

- Foundation •Intermediate •Proficient •Advanced •N/A

Q28 Anonymity of data

- Foundation •Intermediate •Proficient •Advanced •N/A

Q29 Patient consent to disclosure

- Foundation •Intermediate •Proficient •Advanced •N/A

Q30 Disclosing information to immediate colleagues

- Foundation •Intermediate •Proficient •Advanced •N/A

Q31Disclosing information to other agencies

• Foundation •Intermediate •Proficient •Advanced •N/A

Q32 Good practice in record keeping

• Foundation •Intermediate •Proficient •Advanced •N/A

Q33 Changing needs of confidentiality with electronic records

• Foundation •Intermediate •Proficient •Advanced •N/A

Q34 Protecting information against accidental damage

• Foundation •Intermediate •Proficient •Advanced •N/A

Q35 Protecting information against malicious damage

• Foundation •Intermediate •Proficient •Advanced •N/A

Q36 Protecting information against unauthorised access

• Foundation •Intermediate •Proficient •Advanced •N/A

Q37 The implications of privacy legislation

• Foundation •Intermediate •Proficient •Advanced •N/A

Q38 The implications of DF law on privacy legislation

• Foundation •Intermediate •Proficient •Advanced •N/A

Appendix J: Location audit questionnaire

IT Audit

1. Is there a PC in the clinic?
2. Is there a PC connected to the Internet?
3. Is there a PC connected to the Intranet?
4. Do the clinicians have access to a computer connected to the PMS at their point of care delivery?
5. What electronic devices does the clinic use?
6. Does the clinic have a printer?
7. Does the clinic have a scanner?
8. How is information backed up?
9. Is anti-virus software installed and current?
10. Is the system protected against an interruption to the power supply?
11. Is there a log of problems/ errors with the Dental Module, PMS/ MIF purchasing?

Information management

12. Is an IT system used for administration?
13. Is there a patient registry where each patient is identified by a unique identifier?

Governance

14. Has training been provided for knowledgeable consent?
15. Are standard consent forms available?
16. Has awareness training been provided in relation to the implications of racial, minority, discrimination legislation when getting consent?

17. Has awareness training been provided in relation to the implications of treating children when getting consent?
18. Is information provided to patients in relation to the proposed uses of information about them?
19. Are basic security and privacy requirements included in staff induction training?
20. Are basic security and privacy requirements included in staff annual training?
21. Is there any training provision for information security?
22. Is there any training provision for information sharing?
23. Has it been established who owns the data?
24. Is there a log of information security issues?
25. Are there reporting procedures?
26. Does the system force password changes regularly?
27. Are there user access controls?
28. Are lockable rooms/ cabinets available?

Appendix K: DFDS audit questionnaire

IT Audit

1. How is information backed up?
2. Is anti-virus software installed and current?
3. Is the system protected against an interruption to the power supply?

Information management

4. Is there a commitment from all dentists to share data and implement standards across the DF?
5. Is there a patient registry where each patient is identified by a unique identifier?

Governance

6. Has training been provided for knowledgeable consent?
7. Are standard consent forms available?
8. Has awareness training been provided in relation to the implications of racial, minority, discrimination legislation when getting consent?
9. Has awareness training been provided in relation to the implications of treating children when getting consent?
10. Is information provided to patients in relation to the proposed uses of information about them?
11. Are basic security and privacy requirements included in staff induction training?
12. Are basic security and privacy requirements included in staff annual training?
13. Is there any training provision for information security?
14. Is there any training provision for information sharing?
15. Has it been established who owns data?
16. Is there a log of information security issues?

17. Are there reporting procedures?

18. Does the system force password changes regularly?

19. Are there user access controls?

Appendix L: Results of individual questionnaires

	D1	D2	N1	D3	N2	D4	D5	N3	N4	N5
Q1	2	2	3	3	4	1	2	3	3	2
Q2	2	1	2	4	4	1	2	3	4	3
Q3	3	2	3	4	4	1	1	3	4	3
Q4	3	2	2	4	4	2	3	3	4	1
Q5	2	1	2	2	2	2	2	3	4	1
Q6	1	1	2	1	1	1	1	3	4	0
Q7	2	1	3	1	3	2	3	3	4	0
Q8	4	1	3	4	4	3	3	3	4	3
Q9	4	2	3	4	4	2	3	3	4	3
Q10	4	1	2	3	3	1	1	2	4	0
Q11	0	0	0	0	0	0	1	1	1	0
Q12	0	Basic course	CAPS course	Word, excel, oracle, purchasing, pms, mif	Word, excel, purchasing, pms, mif	PMS, purchasing, mif	0	MIF, PMS, IMS	Cert, Diploma, Teachers Dip IT	IMS
Q13	4	1	3	4	4	2	1	3	3	0
Q14	3	1	2	4	4	1	0	3	2	0
Q15	4	2	2	4	4	4	4	3	4	0
Q16	4	2	2	4	4	4	4	3	4	0
Q17	4	2	2	4	4	3	4	3	4	0
Q18	4	2	2	4	4	4	4	3	4	4
Q19	4	2	2	4	4	3	3	3	3	4
Q20	2	2	2	4	3	3	2	2	3	0
Q21	1	2	2	1	1	2	3	2	1	0
Q22	1	1	1	1	1	3	1	2	1	0
Q23	1	1	1	1	1	3	1	2	1	0
Q24	2	3	3	3	3	3	3	2	3	4
Q25	4	0[1]	0[1]	3	4	3	3	2	3	4
Q26	4	0[1]	0[1]	3	4	3	2	3	0	4
Q27	4	4	4	4	4	3	4	3	4	4
Q28	2	4	1	4	4	3	3	3	4	4
Q29	4	4	3	4	4	3	3	3	4	4
Q30	4	4	4	4	4	3	3	3	4	4
Q31	4	4	4	4	4	3	3	3	4	4
Q32	4	4	3	4	4	3	3	3	4	4
Q33	4	2	2	4	4	3	4	2	3	4
Q34	2	3	1	4	4	2	2	2	4	4
Q35	2	3	3	4	4	2	2	2	4	4
Q36	2	3	3	4	4	2	2	2	4	4
Q37	1	1	1	4	4	3	1	1	1	4
Q38	1	1	1	1	1	3	1	1	1	4

Appendix M: Results of location questionnaires

	NS	1 S Bde	4 W Bde	2 E Bde Wing	2 E Bde LBH	2 E Bde Cathal Brugha	DFTC
Q1	Y	Y	Y	Y	N	N	Y
Q2	N	N	Y	N	N	N	N
Q3	Y	Y	Y	Y	N	N	Y
Q4	N	N	N	N	N	N	N
Q5	0	0	Xray	0	0	0	0
Q6	Y	Y	Y	Y	N	N	Y
Q7	N	N	N	N	N	N	N
Q8	DF policy	DF policy (except referrals)	DF policy (except xrays, referrals)	DF policy	DF policy	DF policy	DF policy (except referrals)
Q9	DF policy	DF policy	Intranet DF policy, Internet N	DF policy	DF policy	DF policy	DF policy
Q10	N	N	Y xray server	N	N/A	N	N
Q11	N	N locally	Y	N	No, N/A	N	N
Q12	PMS	PMS, referrals	PMS, referrals by email	PMS	N	N	PMS, referrals
Q13	Y	Y	?? xrays	Y	Y	Y	Y
Q14	N	N	Y	Y	N	N	N
Q15	N	N	Y	N	N	N	N
Q16	N	N	N	N	N	N	N
Q17	N	N	N	N	N	N	N
Q18	Y	Y	Y	Y	Y	N	N
Q19	N	Y	Y	Y	N	N	N
Q20	N	N	N	N	N	N	N
Q21	N	N	N	N	N	N	N
Q22	N	N	N	N	N	N	N
Q23	N	N	N	N	N	N	N
Q24	N	N	N	N	N	N	N
Q25	Y	Y	N	Y	Y	Y	Y
Q26	Y	Y	Y	Y	Y, N/A	Y	Y
Q27	Y	Y	Y	Y	Y, N/A	Y	Y
Q28	Y	Y	y	y	Y	Y	Y

Appendix N: Results of DFDS policy questionnaire

Q1	DF policy
Q2	DF policy
Q3	DF policy
Q4	N
Q5	Y
Q6	N
Q7	N
Q8	N
Q9	N
Q10	N
Q11	N
Q12	N
Q13	N
Q14	N
Q15	N
Q16	N
Q17	Y
Q18	Y
Q19	Y

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