Secondary use of data as a method to improve Data Quality in a theatre setting.

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

2014

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Author Declaration

I declare that the work described in this dissertation is, except where otherwise stated, entirely my own work, and has not been submitted as an exercise for a degree at this or any other university.

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I declare that the work described in this dissertation has been carried out in full compliance with the ethical research requirements of the School of Computer Science and Statistics and the Study Hospital.

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Abstract

This study examined the hypothesis that secondary use of data will lead to improvement in electronic data quality in the operating theatre. The study merged two theoretical approaches, research and Total Data Quality Measurement (TDQM). These approaches were used to measure the impact of secondary use of data and to bring about continuous quality improvement in data quality.

A pretest-posttest design was used to measure the data quality of 148 electronic surgical records against the quality dimensions completeness, concordance and timeliness. Quality interventions were based on secondary use of data from the pretest phase of the study findings and pretest posttest analysis undertaken using the z tests. The p value of significance was set at 0.5%.

The findings showed a non-significant improvement in completeness (88% to 92%, p=0.1288) and concordance (82% to 89%, p=0.1105), and a contrasting reduction in the timeliness (27% to 24%, p=0.3155). The null hypothesis was accepted. There was significant improvement in a number of surgical records for completeness (41% to 58%, p=0.0045) and concordance (33% to 58%, p=0.0000). For individual surgical fields, the data improved significantly in 7 items in the completeness data set and in 3 items in the concordance data set. The gaps in surgical data quality are confirming the procedure code, laterality specification and the timeliness in confirming the surgical procedure code.

The potential for secondary use of data to improve data quality was confirmed.

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Abbreviations

Abbreviation	Full Text
CABG	Coronary Artery Bypass Graph
CAC	Computer-Assisted Coding
CDS	Clinical Decision Support
CMS	Centres for Medicaid and Medicare Service
COPD	Chronic Obstructive Pulmonary Disease
CPOE	Computerized Physician Order Entry
DoH	Department of Health
DoHC	Department of Health and Children
DRG	Diagnostic Related Groups
eHealth	Electronic Health
EHR	Electronic Health Record
EMR	Electronic Medical Record
EPR	Electronic Patient Record
EC	European Commission
EU	European Union
GP	General Practitioner
HCP	Health Care Professional
HES	Hospital Episode Statistics
HI	Health Information
HIPAA	Health Insurance Portability and Accountability Act
HIPE	Hospital In-Patient Enquiry
HIQA	Health Information and Quality Authority
HIS	Hospital Information System
HSE	Health Service Executive
ICD	International Classification of Diseases
ICPC	International Classification of Primary Care
ICT	Information Communication Technology
IS	Information System
IHD	Ischaemic Heart Disease
IT	Information Technology
LOINC	Logical Observation Identifiers Names and Codes
MRN	Medical Record Number
NCRI	National Cancer Registry Ireland
NCPS	National Clinical Programme in Surgery
NTPF	National Treatment Purchase Fund
NLP	Natural Language Processing
OPCS	Office of Population Census & Surveys Classification of Surgical Operations and Procedures
PAS	Patient Administration System
SDU	Special Delivery Unit
SHARP	Strategic Health Information Technology Advanced Research Project
SWOT	Strengths, Weaknesses, Opportunities and Threats
SDE	Structured Data Entry

SNOMED CT	Systematized Nomenclature of Medicine Clinical Terms.
TPOT	The Productive Operating Theatre
UK	United Kingdom
US	United States
USA	United States of America
WHO	World Health Organisation

Glossary of Terms

TERM	DESCRIPTION
Anonymised data	This is data that previously referred to an identifiable person, but that identification is no longer possible (Sheikh 2008)
Classifications/Medical Coding	Classification/Medical coding is the process of transforming descriptions of medical diagnosis and procedure into universal medical code numbers
Clinical Coding	The translation of medical information, relating to a healthcare episode between a healthcare provider and a patient, into alphanumeric code e.g. ICD 10 (HIQA 2013c)
Clinical Terminology	This concerns the meaning, expression and use of concepts in statements in the medical records or other clinical information systems (Rector 1999) e.g., SNOMED CT and LOINC (HIQA 2013c)
Clinician	Clinicians refer to registered professionals (doctors, nurses) having direct contact with and responsibility for patient care.
Coding Classifications Systems	Coding classifications are considered "output" or reporting systems and are also used for reimbursement purposes Examples include ICP2-2, ICD 10, ICD-10-AM, OPCS-4 (HIQA 2013c).
Computer-Assisted Coding	Computer software that automatically generates a set of medical codes for review and validation by professional coders based upon clinical documentation provided by healthcare providers (www.nuance.com)
Computerised Physician Order Entry	CPOE is an electronic system for laboratory tests ordering and medication prescribing as part of patient's hospital treatment.
Confidentiality	The duty which a person entrusts to another on the expectation that it will be kept confidential or which would be regarded to be extreme to disclose (Sheikh 2008)
Consent: Explicit	The data subject must be aware of and understand the purposes for which his/her data are being processed. Explicit consent must specify the particular types of data and the specific purposes for which they may be used(www.dataprotectioncommission.ie)
Consent: Expressed	This is given by a patient agreeing actively, usually orally or in writing, to a particular use or disclosure of information (Sheikh 2008)
Consent: Implied	This is given when an individual takes some action in the knowledge that in doing so, they agreed to a particular use or disclosure of information (Sheikh 2008)
Consent: Informed	The legal requirement for clinicians to explain the risks, precautions, purpose for and potential benefits of a medical procedure or medical research to a patient or their significant other prior to performing a medical procedure or research (Wilson and McEvoy 2012)
Data	Data is raw unorganised facts that need to be processed or organised. Data can be numbers, symbols, words, images and graphics that have to be organised or analysed (HIQA 2013b)
Data Controller	The person who (either alone or jointly or in common with other persons) determines the purpose for which, and the manner in which personal data is to be processed (e.g HSE facility, Research Body, HIQA, GPs)

Data Mining	The extraction of implicit, previously unknown and potentially useful knowledge from large electronic data sets. This technique relies on sophisticated algorithms built into the software e.g., decision trees and cluster analysis (HIMSS 2006)
Data Quality	Data that is complete, valid, accurate, reliable, relevant, legible and available in a timely manner (HIQA 2013a)
Data user	Any user of data or information produced by the national health and health and social care data collection (HIQA 2013a**)**
Data Warehouse	A central storehouse of data that has been extracted from operational data (Galanter et al. 2010)
e-health	The use of information and communication technologies in health to treat patients, pursue research, education students, track diseases and monitor public health (WHO 2011)
Electronic Health Record	A longitudinal electronic record of patient health information across multiple care setting (See Electronic Medical Record). Contains multiple EMR and EPRs which is shared and interoperable across setting
Electronic Medical Record	The computerized record for a patient in a single location of service (clinicians/health professional's office) that includes prior treatment, demographic, immunisation, laboratory, medication, prior history and more depending upon the type of treatment.
Electronic Patient Record	Electronic Patient Record (EPR), which is defined as a longitudinal record of a patient health information within a single institution (e.g hospital or facilities such as care centres)
Health Information	Information used to help make informed health-related decisions or to inform oneself of health-related issues (DoHC 2004)
Healthcare professional	A registered medical practitioner, or nurse, or allied health professionals (e.g physiotherapist, pharmacists, social worker, occupational therapist, speech and language therapist)
Hospital In-Patient Enquiry	HIPE is the principle source of national data on discharges from acute hospitals in Ireland (www.hiqa.ie)
Information	Information is interpreted data (See Data). It relates data (facts, figures, text) that has been processed or analysed to produce something useful (HIQA 2013a).
Information Confidentiality	The duty to respect a person's healthcare information which the person entrusts on the expectation that it will be kept confidential, and not be misused or wrongfully disclosed (Sheikh 2008)
Information Governance	The arrangements in place to manage and to ensure that personal information is handled legally, securely, efficiently and effectively. (HIQA 2013a).
Information Privacy	Privacy is the right of a person to control information about self, including the collection, use and disclosure of that information (Sheikh 2008)
Informed Consent	The legal requirement for clinicians to explain the risks, precautions, purpose for and potential benefits of a medical procedure or medical research to a patient or their significant other prior (Wilson and McEvoy 2012)

International Classification of Disease (see glossary)	ICD is clinical coding for epidemiology reporting, health management purposes and clinical use in acute and primary care settings (HIQA 2013c)
Interoperability	Interoperability is the ability of two or more systems or components to exchange information and to use the information that has been exchanged (Benson 2009)
Key Performance Indicators	KPIs are specific and measurement elements that can be used to assess quality of care (HIQA 2013b)
Pay-for-Performance	Financial incentives for healthcare providers to reach certain performance metrics or benchmarks (Wilson and McEvoy 2012)
Personal Data	Data relating to a living individual who is or can be identified either from the data or from the data in conjunction with other information that is in or is likely to come into the possession of the data controller (Data Protection Act 2003)
Primary use of information	Data that is collected in the course of providing direct patient healthcare and used to provide health or social care to the data subject
Pseudonymisation	This involves the use of a coding system to protect the identity of an individual to whom the information relates (HIQA 2013a).
Scheduled care	Planned patient admission to a hospital for treatment (ie admission for a surgical or medical procedure).
Scorecards	Scorecards deliver mission-critical financial and operation information in an easy to understand visual electronic format for convenient and timely reporting (Harrington et al. 2009)
Secondary use of information	Information collected in the course of providing care, being used for purposes other than direct patient care. This includes managing, delivering, auditing, evaluating existing or potential health services, for planning services or health research (HIQA 2013a)
Structured data	Data that resides in a fixed field within an electronic record or file
Systematized Nomenclature of Medicine Clinical Terms	SNOMED CT is used to support healthcare professionals when recording data entries of practice (procedures, body structures, clinical findings, pharmaceutical and biological products) (HIQA 2013c)
Terminologies	Are structured lists of terms that are used to capture clinical information at the point of care (HIQA 2013c)
The National Treatment Purchase Fund	The NTPF is an independent stationary agency established by the government to oversee the faster access to elective hospital based treatment for public patients.
The Productive Operating Theatre (TPOT)	TPOT is a continuous improvement programme to improve patient outcomes and operating theatre performance (www.info@rsci.ie)
The Special Delivery Unit	The function of this unit is to set and implement target times for waiting for scheduled and unscheduled care and access to diagnosis in acute hospitals in Ireland.
Theatre utilisation	A qualitative measure of theatre time usage (Faiz et al. 2008)

Chapter One Introduction

1.1 Introduction to Dissertation

Secondary use of health data is an important resource for healthcare organisations. It is used to monitor and evaluate services with a view to optimising the efficiency and quality of healthcare. Rapid expansion of technology means that clinicians have increasingly greater amounts of data available. To be useful, this data must be high quality and "fit for purpose"(HIQA 2012b; CIHI 2009). The quality and management of healthcare data is a patient safety issue and therefore it needs to be aligned with legislation requirements and national standards (Data Protection Commissioner 2007; HIQA 2012c). Furthermore, there are huge incentives for acute public hospital to improve their data and information quality ahead of pay for performance incentives (Faulconer and de Lusignan 2004; DoH, 2013b). This is especially relevant to scheduled care, and specifically surgery (RCSI, 2013). There is an abundance of literature and research on secondary use of data and data quality internationally. However, the potential of secondary data to improve data quality has not been widely researched in Ireland and little is known about the process of measuring and improving data recording.

The focus of the study is to investigate the secondary use of data as a means of improving data quality. Three dimensions of data quality were measured using surgical data from a large teaching hospital in Ireland. This study embraces the principles of total data quality management (TDQM) to improve the data. The aims, objective and methods used to conduct this research are outlined in the following sections.

1.2 The Purpose, Aims and Objectives of the Study

Purpose

The purpose of the study is to assess and improve the quality of data in a theatre setting. This in turn will lead to improved patient care.

Study Aim

To determine if quality measures based on the secondary use of data lead to improvement in data quality.

The Objectives

The study objectives were set to meet the study aims. These are as follows;

1. To develop a methodology for the assessment of data quality

2. To measure data completeness, concordance and timeliness pre and post quality interventions.
3. To identify significant gaps in data quality
4. To identify the effectiveness of quality based strategies on improving electronic surgical data quality.

1.3 Motivation for the Study

The researcher had a number of motives for conducting this investigation. First, to learn more about secondary use of data and data quality. Second, to ease the process of carrying out objective data quality measurement. Third, to facilitate accurate reporting of theatre activity at local and at national level. Fourth, to facilitate the move toward a paperless system for recording theatre activity.

1.4 Research Methodology

A pretest-posttest quasi-experimental design was used to measure the effects of quality interventions on data quality. Electronic data in a theatre setting was assessed against three quality dimensions; Completeness, Concordance and Timeliness. The data was measured before and after quality interventions were introduced and a pretest-posttest analysis undertaken.

The investigation was carried out using a five step process, conducted in two phases (pretest phase 1 and posttest phase 2). Data was collected and quality initiatives implemented in phase 1. Data was recollected, pre and post analysis conducted and the findings reported in phase 2. The *z*-test was used to test the statistical significance. A *p*-value of <0.05 was considered significant. The research process is shown in figure 1.

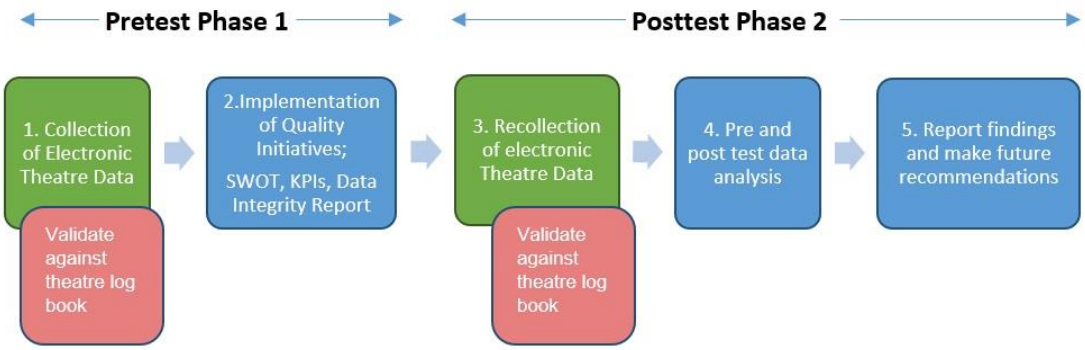

Figure 1: Study Process

The study is underpinned by TDQM concepts of defining, measuring and improving data quality (Wang 1998). This approach influenced how the data was constructed, the assessment measures used and the sustained improvement measures employed. The feedback from the study phase 1 was presented to clinicians using a Strenghts Weaknesses Opportunities Threats (SWOT) analysis framework. The findings were also used to guide KPI development. A data integrity report was implemented to help clinicians identify missing data fields.

Ethical approval was gained from the hospital Clinical Research Ethics Committee and Trinity College Dublin (TCD) prior to commencement of the study.

1.5 Overview of the Dissertation

The dissertation is structured as follows;

- Chapter two contains an extensive review of the literature in relation to secondary use of data, data quality and measures to improve data quality.
- Chapter three outlines the study design and methods, analysis, ethical considerations and the quality interventions utilised.
- Chapter four outlines the quality initiatives and presents the findings from the pretest phase 1.
- Chapter five provides an analysis and discussion of the findings and the future state of measuring data quality.
- Chapter six provides the study conclusion along with the limitations of the study and recommendations for future work.

Chapter Two Literature Review

2.1 Introduction to Literature Review

The literature review examines important aspects of secondary use of data and data quality. Key concepts relating to the study are explored enabling definitions to be set. Details are provided of how the literature was sourced. The review looks at ICT in Ireland, the value and benefits of secondary data and the legislation and data protection requirements. Data quality is reviewed in terms of importance, the taxonomy of quality dimensions and the challenges of researching this concept. The fallout from poor data quality and the factors that inhibit data quality are reviewed along improvement measures such as human factors, quality management and technical interventions.

2.2 Key Concepts

The key concepts reviewed are primary and secondary use of data, data and information, data quality and improvement.

The primary use of data relates to data that is collected in the course of providing direct patient healthcare. The data is used to deliver health and social care to individuals. Secondary use of data also relates to data collected in the course of providing direct healthcare, but it is used "*for any purpose other than that for which it was originally collected*" (HIQA, 2012a). Secondary use of data is the reuse of healthcare data for audit, research, billing, performance monitoring, service planning and government department reporting purposes (HIQA 2012a).

In this study, data is defined as raw unorganised facts that needs to be processed or organised. Information is data that has been processed and interpreted into something useful (HIQA 2013b). The use of information and data are used interchangeably throughout the study. This interchangeably frequently occurs when addressing quality issues in practice (Gao et al 2012). Data quality and information quality will also be used interchangeably throughout the study.

Data quality is defined as "the totality of features and characteristics of a data set", that satisfies the needs of the intended users of the data (HIQA 2013b). This definition is widely adopted in the literature, coinciding with the belief that data quality should focus on satisfying the needs of data users or consumers, as ultimately they are in the best position to judge if data is "fit for purpose" (Wang and Strong 1996; CICI 2009, Almutiry et al 2013).

Data quality is operationally defined and measured along common and widely used dimensions (HIQA 2012b; Long et al 2001). Data quality dimensions are defined as "*a set of data quality attributes that represent a single aspect or construct of data quality*" (Wang, 1996 pg 6). HIQA (2012b) have identified seven internationally accepted dimensions to assess and compare data quality (accuracy, completeness, relevant, reliable, timely, valid, legibility) (Figure 2). Two of HIQA's definitions, completeness and timeliness, are adopted in this study.

Figure 2: Dimensions of Data Quality (HIAQ 2013a)

Data quality is closely aligned with improvement and the steps, strategies and techniques to achieve this. The researcher utilised a TDQM framework, as this is specifically designed to guide the measurement, analysis and improvement of data quality. The TDQM framework was developed by Wang (1998) with the aim of providing an end-to-end quality improvement process for information manufacturing. The cycle consists of four processes that implement a continuous quality improvement process; define (identifies important dimensions), measure (produce metrics), analyse (identify root cause) and improve. The TDQM theoretical framework is built on the principles of Total Quality Management, with important differentials. Data is used by multiple people at once and is not depleted, timeliness has an intrinsic property and believability does not have a counterpart in product manufacturing (Wang, 1998). The underpinning belief is that data is viewed as a

product that is delivered to a consumer, therefore it needs to be 'fit for purpose' (Wang and Strong 1996). The next section outlines the background to the literature review.

2.2 Background to Literature Review

Healthcare is becoming more computerised, thus larger volumes of data are being generated and stored in the one location. This offers great opportunities to use the data to improve decision making and care delivery, monitoring diseases and research (Teasdale et al 2007; HIQA 2012a; Hahn et al 2013). Safe and efficient healthcare delivery depends on data that is easily accessed, accurate, secure, and is delivered to the right person at the right place (DoH 2013a). Health Information and Quality Authority (HIQA), the regulating body who oversee health information quality in Ireland, clearly state that correct, up-to-date health and social care data must be made available to service users, Health Care Professionals (HCPs), administrative staff and government departments. It should be of the highest quality, be "*collected once and used many times*" and should be "*fit for purpose*" (HIQA 2013a, pg. 5).

Concerns about the data quality and the challenges of generating data and research this are widely published (Weiskopf and Weng 2013a; Chan et al 2010; HIQA 2012c). Researchers suggest that data quality is poorly defined, poorly collected and reported, and that the accuracy of electronic data capture is often unsatisfactory (Breil et al 2011; Weiskopf and Weng 2013a; Chan et al 2010; Weiner and Embi 2009; Teasdale et al 2007). This poses a challenge, as it diminishes the ability of secondary data to inform clinical decision making (HIQA 2012a; de Lusignan et al 2010; Audit Commission 2003; NTPF, 2013). Secondary use of data is also challenged by ethical and privacy issues (Data Commissioner 2014). Access to and usage of healthcare information is subject to stringent Freedom of Information and Data Protection Legislation.

The topic of secondary use of information is still in its infancy in Ireland, which offers huge scope for further investigation. The generation, quality, safety and management of electronic healthcare information will be a requirement in every healthcare setting in Ireland (HIQA 2012d; HIQA, 2012c). Furthermore, major healthcare reform is taking place in hospital resource allocation, as outlined in "*Money Follows the Patient*" (DoH 2013b), further intensifying the need for high quality data. With this in mind, the potential of

secondary use of data to improve data quality is timely. The next section outlines the search strategy for the study.

2.3 Search Strategy

An extensive review of the literature was generated to inform the study. A large number of articles were sourced, with over 220 meeting the inclusion criteria. Table 1 outlines how the literature was searched and sourced, the types of materials used and the search terms applied. The primary data source of information was databases. The search was limited to English literature from the year 1990 to 2014. Electronic Health Record (EHR) implementation was excluded from the search.

Table 1: Literature Sources

Databases	Limitations	Other Sources	Types	Search Terms
Stella Seach	English	Snowballing	Journals	Data quality
Google Scholar	Years 1990 to 2014	Expert Opinion	Books	Quality
Web of Science		Networking	Conference Material	Secondary use of data
TCD Ebsco			U Tube	Secondary data
Pubmed			Thesis	Clinical information system
Science Direct			Reports	Measurement
ProQuest			Laws and Legislation	Healthcare
CINAHL			Websites	Business Intelligence
JSTOR			Newspapers	Surgical wait times
The Cochrane Library				Operating theatres
				Data Protection
				Privacy
				Legislation
				KPI, Performance Indicators
				SWOT analysis and healthcare
				Technology standards
				Terminologies
				Classifications

2.4 Health Information Technology within the Irish Context

In Ireland, health information technology has some way to go before its full potential is reached. Data is generated mostly from single site electronic systems and/or Electronic Medical Records (EMR). The Electronic Health Record (EHR) is still at an early stage of development (DoH 2013a; DoHC 2004).

It is widely recognised that Ireland has a low level of investment in health information (HI) in general and Information and Communication Technology (ICT) in particular. This has implications for meeting the complex information requirements across the health sector (DoHC 2004). The National ICT spend in healthcare is approximately 0.85% of the total health budget, relative to the European Union (EU) range of 2-3% (DoH 2013a). This stunts

eHealth progress and contributes to a fragmented, non-standard ICT infrastructure, which lacks a system of unique identification (DoH 2013a).

On a positive note, great efforts have been made over the last 10 years to progress the ICT, secondary use of data, and the data quality agendas. The Department of Health (DoH), with responsibility for health information policy and related legislation, has published the "*National Health Information Strategy*" to prepare the way for the implementation of the EHR, and the more recently has published an eHealth strategy for Ireland (DoHC 2004; DoH 2013a). The eHealth strategy sets out plans for access to high level healthcare anywhere in the EU and calls for the realignment of ICT spend to come in line with the EU average. In accordance with the Health Act 2007, the Department of Health and Children (DoHC) has appointed the independent regulatory authority, HIQA to oversee the implementation of the Health Strategy and to set and monitor health information (HI) standards (Health Act 2007).

Legislation has also improved with the enactment of the Data Protection Act (Government of Ireland 1988 and 2003) and the Freedom of Information Acts (Government of Ireland 1997 and 2003). These acts serve to protect individual's right to privacy and the right to access information (personal and non-personal). Data protection will be discussed in greater detail in section 2.6.1. In the near future, the Health Information Bill will be published. This will provide a legislative framework for better health information governance, and will progress the development of the unique identifier for individuals and organisations (Department of the Taoiseach 2014). Such developments will help pave the way for the roll out of the EHR in Irish healthcare (DoH 2013a). The next section will outline the added value of secondary data usage.

2.5 Value of Secondary Data Usage

Secondary data usage is an important resource for government bodies, healthcare organisations, researchers and industry (DoH 2013a, HIQA 2013a). Governments across many countries such as the United States of America (USA), Canada, England, New Zealand, Australia, Central Europe and Ireland have called for greater reuse of data because of the many recognised benefits (HIQA 2013a; Breil et al 2011; Safran et al 20; Haux et al 2002; Garrett 2010).

Key national repositories using secondary data include the Hospital In-Patient Enquiry (HIPE) system, the National Cancer Registry Ireland (NCRI) and the Health Research Board (HRB) amongst others. The HIPE system shows patient activity in acute hospitals in Ireland. This information is used by the Department of Health (DoH) and the Health Service Executive (HSE), amongst others, to plan for the provision of acute hospital services. The NCRI provides information on the occurrence, treatment and mortality rates of cancer to HCPs and members of the public. The HRB enables and supports high quality research in areas such as Data Protection, Intellectual Disability and Mental health. These developments demonstrate the potential of ICT and the value placed on secondary data usage to support the planning, monitoring and delivery of healthcare in Ireland.

The value of secondary data is also wide ranging in the operating theatre setting. The main reasons cited in the literature are as follows;

1. To inform service delivery and safe care. Poorly delivered surgical care can increase mortality rates, increase costs and is unsatisfactory for the patient and the healthcare organisation alike (RCSI 2013).
2. To reduce running costs and increase efficiency. Operating theatre is an expensive service with daily costs of approximately €12,000 per theatre (Connors 2011) and up to 2.5m per year (50%=variable) (RCSI 2013).
3. To achieve greater theatre capacity and enhanced patient flows. There are maximum allowable wait times for surgery, with financial penalties for poor performance (NTPF 2013).

Secondary use of data has been widely used to inform wait times to access surgery, utilisation of theatre time and capacity, and staff workload (Pandit et al 2012; Delaney et al 2010; Faiz et al 2008; Iyer et al 2004). Through the analysis of secondary theatre data, Pandit et al (2012) showed that theatre utilisation and surgical start times are poor indicators of theatre efficiency, suggesting that better surgical list scheduling is required.

The Royal College of Surgeons in Ireland (RCSI) report "*Model of Care for Acute Surgery*" suggests that the national measurement of surgical services is one of the key ways to increase the safety and efficiency of surgical care in Ireland (RCSI 2013). However, only a very limited amount of data is measured. This is about to change, with the introduction of national surgical performance measures in surgical mortality, orthopaedic joint

replacement and intensive care. Additionally, greater links will be established with the HIPE system in order to improve the accuracy of data locally and nationally (RCSI 2013). Secondary data is available in greater quantities, ensuring greater statistical power and generalisation of findings (Lockwood 2006). Therefore, the information generated has a greater capacity to inform safety, efficiency and the financial gains required in the theatre setting (NTPF 2013; RCSI 2013).

In the primary care setting, the benefits of secondary use of data is derived mostly from population health, business processes and research. Routinely collected data in general practice setting has helped define primary care, particularly in relation to chronic disease management (de Lusignan et al 2005). Great volumes of data are now collated allowing a meta-analysis of diagnosis, complications and incidence of comorbidities such as heart disease, the impact of the influenza and pneumococcal vaccine and the incidence of smoking and obesity rates (General Practice Data Governance Council 2011).

Secondary data is also used to assess for pay-for-performance. In the UK, 30 to 40% of GP income depends on achievement against pre-set quality indicators, with a large focus on the care of chronic conditions (e.g., Diabetes, hypertension) (Teasdale et al 2007). In the near future, Irish hospital funding will be based on a prospective case-based payment system, requiring the extraction of health information from EHRs (DoH 2013a). Secondary use of data will produce substantial benefits in assisting clinical coders to allocate diagnostic related groups (DRGs) and case mix for patient admissions, which in turn will determine pay-for-performance (Craswell et al 2013).

For researchers, secondary data is a rich source of information which has advantages over other methodologies, such as surveys and case studies. It is removed from any goals and objectives of researchers, eliminating bias and it is economical as it requires fewer resources than other methodologies (Rabinovich and Cheon 2011; de Lusignan and van Weel 2006). Furthermore, larger sampling allows the generation of new ideas and new insights into population health, which is very informative for researchers and recipients alike (Rabinovich and Cheon 2011; Lockwood 2006).

Large research repositories have been used to inform conditions such as asthma, diabetes, epilepsy, postmenopausal osteoporosis, fractures and mineral density scores as well as

medication management (Garrett 2010; Safran et al 2007; Teasdale et al 2007). Through the use of data mining, the healthcare group Kaiser Permanente identified a link between the non-steroidal anti-inflammatory drug Rofecoxib (Vioxx) and a high risk of cardiovascular events. This was confirmed in a large scale study (Ray et al 2002), leading to the withdrawal of the drug from the market in 2004 in the interest of public safety.

The volume of data available to researchers is set to increase. With the NHS "*National Programme for Information Technology*" (NpfIT), considerable time and financial investment, in excess of £12.4 billion, is in place to centralise a national database of medical records (Brown et al 2010; House of Commons 2013). This will increase the amount of data available for health research (Brown et al 2010). Similarly, in the United States (US), the fall out of the American Reinvestment and Recovery Act of 2009, with a $36 billion investment to expand health IT, will result in greater amounts of data available (Hoffman and Podgurski 2011). The ehealth strategy and upcoming Health Information Bill may have similar effect in Ireland (Government of Ireland 2013; DoH 2013a).

Secondary data is also recognised as an important commodity. Garrett (2010) referred to US health data as a national treasure, surpassing the value of the gold bars in Fort Knox. Data is currently being used to support outcome based studies, rendering financial gains is excess of $900 million according Pricewaterhouse Coopers (Garrett 2010). Healthcare organisations in the US are now looking outside their organisation to market their secondary data for the purpose of disease management, clinical trials and as a new revenue source (Safran et al 2007; Garrett 2010).

Similarly in Europe, personal data has acquired enormous value. Boston Consulting Group estimate the value of EU citizen data was €315 billion in 2011 with the potential to rise in value to nearly €1 trillion in 2020, due to the explosion in the quantity and quality of personnel data available in the digital market (Europa 2014). The Telegraph reported that the Institute of Actuaries was able use 13 years of NHS patient data – covering 47 million patients, and sell it to insurers to help them "refine" insurance premiums. This report comes ahead of a £50 million data-sharing plan at NHS England (Donnelly 2014).

The sale of secondary data for commercial use has led to public concern (Hill et al 2013; Safran et al 2007; Europa 2014). In the following section the laws and regulations pertaining to secondary use of data in healthcare will be explored.

2.6 Data Protection, Research and Consent

Concerns over inappropriate use of personal data has led to stringent laws and regulations to protect public privacy and confidentiality (Data Protection (Amendment) Act 2003). Balanced with this, is the counter argument that access constraints on personal data are too strict, preventing reuse of secondary data for much needed clinical research. The UKs Academy of Medical Sciences has suggested that legislation is hindering medical research (Brown et al 2010). These issues will be discussed in the following sections.

2.6.1 Data Protection Overview

Data protection and privacy is a fundamental right in the EU (Europa 2014), which is strictly enforced by the European Commission (EC). Data protection principles incorporates data collection, storage of personal data and the data controller's responsibility for ensuring that data is processed fairly and lawfully (Data Protection Commissioner 2014b and 2007). The concept of 'privacy' relates to an individual's right to control information about themselves (Sheikh 2008).

According to Greenleaf (2012) 89 countries have adopted data protection laws across Europe, Latin America, the Caribbean, Asia and Africa, demonstrating worldwide awareness. The United States (US) has not adopted a uniform information privacy law. Instead it aligns itself with industry-specific legislations, which facilitates information flow and operation profit over individual's rights to control their own data (Greenleaf 2012). In order to bridge the gap between US and European personal data laws, the EC and US Department of Commerce developed a "safe harbour" framework in 2000. The EC is currently taking action to further protect the flow of transatlantic data flow for EU citizens by making the Safe Harbour safer (Europa 2014).

2.6.2 Informed Consent and Research

Uncertainties can arise over the ownership of health information. In some instances it is seen that data belongs to the person to whom it relates, and the health professional/organisation is the custodian of that information (DoHC 2004). Some clinicians and researchers are of the view that raw patient data is owned by the healthcare organisation. Consequently, patient's consent should not be required to conduct internal audit and research (Safran et al 2007). The data protection laws however hold an opposing

view by stating that no one can "own" another person's personal data and there must always be a special basis for use (Brown et al 2010).

According to HIQA's report on "*International Review of Secondary Use of Personal Health Information*" (HIQA 2012a), variation in the supporting laws and guidance exits across the four countries reviewed; England, Canada, New Zealand and Australia. In Ireland, information which cannot be linked to the patient puts it outside The Data Protection Acts 1988 and 2003. Data can be accessed once the patients' rights to privacy is respected and adequate safeguards are in place to protect and maintain confidentiality of personal data. Confidentiality is defined as the duty to respect personal health data (Sheikh 2008).

The right to privacy is enacted by informed patient consent or anonymisation of the patient's record (Data Protection Commissioner 2007, HIQA 2012a). If anonymisation is not possible, pseudonymised data can be used in conjunction with appropriate safeguards. 'Data Anonymisation" is defined as the removal of an individual's identifiable information and 'pseudonymisation' is the use of a coding system to protect the identity of an individual (HIQA 2013a).

The Data Protection (Amendment) Act 2003, brings a new concern to researchers in Ireland, as the enforcement of Article 7, Directive 95/46/EC requires "explicit consent" prior to the processing of personal data (Sheikh 2005). Explicit consent stipulates that the data subjects must be aware of and understand the purposes for which his/her data are being processed (Data Protection Commissioner 2014b). Currently, Ireland is awaiting a legislation bill which brings the prospect of clear definition of primary and secondary data definitions and patient's involvement.

Discussions are taking place in Europe regarding standards for patients wishing to opt-out from EHR record (Data Protection Commissioner 2007). If sanctioned, it is likely to have huge clinical significance and resource implications for IT departments.

2.6.3 Consent for Secondary Use of Data in Ireland and Internationally

2.6.4 Best Practice

The general consensus is that patient's identifiable data should be anonymised, and all identifiable information removed for secondary purposes (HIQA 2012a). The Caldicott Committee report 1997, offers the following advice on patient identifiable information.

"*All items of information which relate to an attribute of an individual should be treated as potentially capable of identifying patients and hence should be appropriately protected to safeguard confidentiality"* (Caldicott 1997, pg 3).

Best Practice Guidance

1. When processing sensitive health data, the provision for explicit consent is considered best practice.
2. Patients should know what could happen to their data, the safeguards in place for data protection and have the opportunity to consent or refuse consent for use of their data for purposes not related to direct treatment.
3. Patient should be informed of their data usage as soon as possible following presentation at the health organisation (e.g., in a patient information leaflet) and thereafter as necessary.
   (Data Protection Commissioner 2007).

The ultimate legal responsibility for ensuring the confidentiality of data and securing any further consent lies with the data controller (e.g., HSE facility, Research Body, HIQA, GPs). The data controller is also responsible for permitting access by external researchers, which has particular relevance for secondary use of data. In the Case Study 1/97, a complaint was upheld by the Data Commissioner following a finding that the hospital failed in its obligation to obtain a patients data fairly for research purposes and there was a failure to disclose the use of personal data before it was used (Data Protection Commissioner 2014a). Where data is collected for one purpose, it may not be subsequently be used for a separate unrelated purpose without the consent of the data controller. It was observed in the case MS v. Sweden, that secondary use of data without consent was seen as intrusion of an individual's privacy (Sheikh 2008, pg 22).

2.6.5 Research and Public Views

Public attitudes towards the use of their health information for medical research is favourable, but misuse of information or its use for commercial gain is a concern (Hill et al. 2013). A study by Buckley et al (2011) showed the Irish public are in favour of sharing their personal health data with researchers, within opt-in, ongoing consent arrangements. In general, patients seem to have a poor level of understanding of the health information being recorded, the safeguards in place to protect this information, its use in research and

the difference between confidential and anonymous data. It is strongly recommended that public are better informed of the types and benefits of public health research and the processes in place to protect their privacy (Buckley et al 2011; Hill et al 2013; Safran et al 2007; Sheikh 2008).

The next section will look at the all-important dependency between secondary use of data and quality.

2.7 The Importance of Data Quality

High quality data is essential to monitor healthcare services (Spencer 2011). This is evident in HIQA's "*Guidance on developing Key Performance Indicators*" document, which states that accurate performance measurement is dependent on good quality, accurate information (HIQA 2013b). Likewise, the "Better Metrics" project in the UK clearly identifies the importance of the availability of high quality data for KPI development (Whitty and Crump 2005).

Good data quality, and "fit for purpose" information is intrinsically linked with good decision making (Audit Commission 2009). The Audit Commission (2009) (Figure 3) outlines the stages in producing and using information and the strong links between good quality data and good quality decisions.

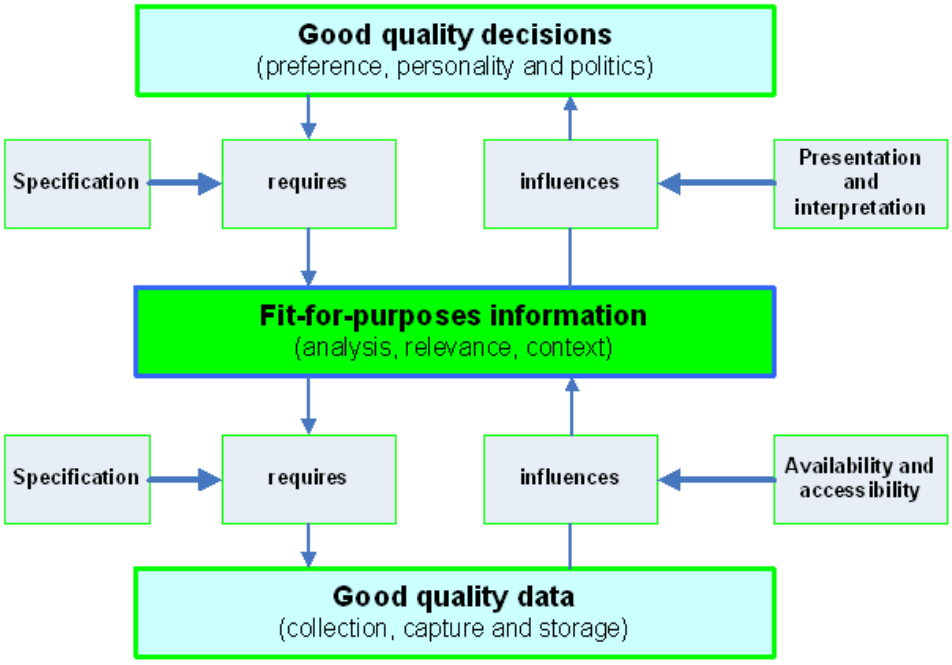

Figure 3: Stages in producing and using information (Audit Commission 2009)

A report by the National Treatment Purchase Fund (NTPF) strongly suggests that decision making is dependent on good data quality. This in turn is linked to the successful delivery of scheduled care in Ireland (NTPF 2013). Difficulties arise when data is poor quality. The impact of this will be discussed in the next section.

2.8 The Impact of Poor Data Quality

Data quality is a patient safety issue (Spencer 2011). Missing, incorrect and non-retrievable patient data poses a potential threat to the quality of care delivered to patients and can lead unsafe healthcare decisions (Mikkelsen and Aasly 2005; Spencer 2011; Linder et al 2012). A systematic review by Chan et al. (2010) found wide ranges of data completeness for blood pressure reading, and smoking status and high incidences of missing data for blood results. Hahn et al's (2013) study showed great variation in data quality across three study hospitals (2 private and 1 public) in an urban Kenyan antenatal care (ANC) clinic setting. This led to difficulties in assessing and comparing data quality. Concerns about data quality can also undermine practice changes required to support secondary data use, and can lead to end users mistrust (Tolar et al, 2012).

Poor quality data, such as inaccurate or incomplete patient documentation, can have an adverse effect on healthcare organisations resource allocation, resulting in delayed, reduced or denied reimbursement (Novitsky et al 2005). Hospital funding is now allocated on the basis of population data in many countries across Europe (WHO 2011). Consequently, data accuracy is strongly linked to revenue sources (Craswell et al 2013; Hahn et al 2013; DoH 2013b).

The monitoring of services, such as the operating theatre, requires good data generation to inform strategic planning. Failure to produce good quality data means that key players such as surgeons, anaesthetists and nurse managers are not objectively informed about their use of theatre, weakening their role in improving theatre performance (Audit Commission 2003 page 30). The Audit Commissioners review of national operating theatres in the UK found the quality of information to be poor (Audit Commission 2003). One quarter of theatre operating hours were missing in at least five per cent of cases, there was no formal start and finish times of scheduled lists in some units and no association between information on the use of theatre time and actual performance. The report concludes that the quality and impact of information needs to improve substantially across

theatre units. Furthermore, core theatre data should be recorded, analysed and management reports produced, allowing assessments of performance to be compared against standards and trends (Audit Commission 2003).

As seen in previous sections, the impact of poor data quality has a profound effect on the effectiveness and safety of healthcare delivery and on research generation. The next section identifies clinical factors that challenge data quality.

2.9 Reasons for Poor Data Quality

There are many reasons for poor data quality. Illegibility of hand written records is one of frequently cited reasons for poor data and it is a known source of medical error (Farzandipour and Sheikhtaheri 2009; Häyrinen et al 2008; Wrightson 2010; Schedlbauer et al 2009). In recognition of this, legibility it is one of HIQAs seven dimensions of data quality (HIQA 2012b). Missing data is another reasons cited for poor data quality. Clinical information recorded within free-text sections of the EHR is challenging to retrieve and can be missed (Chan et al. 2010, Roukema et al. 2006, de Lusignan et al. 2005, General Practice Data Governance Council (GPDGC) 2011). Poor data accuracy impacts on data retrieval, and prevents timely access to data (Morrison et al 2013; Mikkelsen and Aasly 2005).

Inadequate information technology infrastructure, a lack of integration between systems can also impede data quality (DoHC 2004; HIQA 2012e, 2013c). According to Berler et al (2005), a mesh of ICT systems are implemented in healthcare that are not compatible and interoperable even within a single hospital environment. "*Interoperability is defined as the ability of two or more systems or components to exchange information and to use the information exchanged*" (Benson 2009). Hahn et al (2013) showed that poor integration between disparate systems resulted in difficulty accessing laboratory data, the loss of critical blood results, and caused a significant decrease in the quality of information.

Inconsistent use of standards, such as ICD 10 for coding disease and procedures, is another factor which adversely affects the completeness and accuracy of data (Spencer 2011 ; Spencer 2012; Tolar and Balka 2012). A study by de Lusignan et al (2005) showed that a lack of unformed procedure coding led to missed osteoporosis data in general practice computer records. De Lusignan et al (2010) showed that misclassification, misdiagnosis and miscoding of diabetes (Read codes C10E for type 1 Diabetes Mellitus (DM) and C10F in

type 2 DM) ranging from 13.1% (n=930) in the UK CONDUIT study to 14.8% (n=4363) in the QICKD study, leading to an overestimation in the prevalence of diabetes.

While technical problems contribute to data inaccuracies, it is widely recorded that users of clinical information systems play a critical role in the success or otherwise of data quality capture. This will be addressed in the following section.

2.10 Inhibiting Factors to Data Quality in Clinical Practice

A number of factors inhabit data input as shown across studies (Morrison et al 2013; Craswell et al 2013; Hahn et al 2013). The main findings in these studies are summarised as follows;

- A low priority is assigned to this non-clinical activity.
- There is a reluctance to enter data that is not normally required for direct care.
- The extra work required to repurpose data for research and auditing is conflicting with the clinical workload.
- There is a lack of involvement in report generation and poor feedback of this information.
- Computer access can be problematic, as the times and locations for data entry may limited.
- Lack of computer training and skills.

Integrating ICT with healthcare can be challenging and problematic. Healthcare is a strong people-centred sector and ICT can be seen as an intruder to the HCPs way of conducting their care (Berler et al 2005). If this is to be overcome, ICT need to provide service orientated solutions and focus on people suggests Berler et al (2005). Berler et al views are summarised as follows;

1. A level of mistrust exists between different specialities, healthcare institutions and HCPs. This is preventing information sharing and structured data collection.
2. There is a technological gap between HCP and technology experts.
3. Legal requirement and confidentiality of personal data are a concern for HCPs, particularly with the move to a structured EHR.
4. Industry has focused on creating mostly small-scale products, resulting in lack of an all-encompassing HIS with end-to-end solutions.

5. There is a lack of leadership, vision and willingness to re-engineer health-care processes for the benefits of efficiency and quality of care delivery.
6. Achieving user acceptability and usability is a challenge. A system that is not accepted by the user is frequently the system with poor data quality. Systems need to be user friendly, have high speed retrieval and ease of access.

While these points are based on the opinions of Berler et al (2005), they are widely supported throughout the literature (Berner et al 2009; Spencer 2012; Eley et al 2008; Data Protection Commissioner 2007). The following section reviews the measurement of data quality.

2.11 Data Quality Measures

According to McGilvray (2010), data quality cannot be defined, measured or managed without understanding the attributes and dimensions of data quality.

2.11.1 Taxonomy

There is no general agreement on which set of dimensions define the quality of data nor the exact meaning of each dimension (Batini et al 2009; GPDGC 2011). This sentiment is echoed across numerous studies (Chan et al 2010; Weiskopf and Weng 2013a; Hogan and Wagner 1997 Cruz-Correia et al 2013). For instance, Weiskopf and Weng (2013a) identified five common quality dimensions (completeness, correctness, concordance, plausibility and currency). The Institute of Medicine identifies four quality dimensions relevant to electronic records (completeness, accuracy, legibility and meaning) (National Research Council 1997). The Canadian Institute for Health Information (CIHI) defined five dimensions of data quality (accuracy, timeliness, comparability, usability and relevance) (CIHI 2009). Batini et al 2009 claimed that accuracy, completeness, consistency, correctness and timeliness were the most basic set of dimensions to measure data quality. Wang and Strong's (1996 pg 22) framework shows that data should be "*intrinsically good, contextually appropriate for the task, clearly represented and accessible to the consumer*". In Ireland, HIQA outlines seven dimensions to describe data quality, as outlined previously in section 2.2. Table 2 outlines a number of data dimensions and associated definitions.

Table 2: Data Quality Dimensions and Definitions

Dimensions	Definitions	Author
Accuracy	The proportion of recorded observations in the system that are correct. Accuracy is calculated two ways; 1. Recorded observations that are correct 2. Observations that are actually completeness.	Hogan and Wagner (1997)
	Accuracy refers to how closely the data captures what it is designed to capture.	HIQA (2012b)
Completeness	The proportion of observations that are actually recorded in the system.	Hogan and Wagner (1997)
	Data that has all the items required to measure the intended activity or event.	HIQA (2012b)
	The truth about a patient is present in the EHR.	Weiskopf and Weng (2013a)
Prototype definitions of Completeness	The presence of the following four elements: *Documentation*: all observations are recorded *Breadth*: all desired types of data are present. *Density*: a specified number of data points over time. *Predictive*: sufficient information to predict a phenomenon of interest.	Weiskopf et al. (2013b)
Correctness	The element that is present in the EHR is true.	Weiskopf and Weng (2013a)
Reliable	Data is collected consistently over time and reflects the true facts.	HIQA (2012b)
Concordance	Agreement between elements in the EHR, or between the EHR and another data source.	Weiskopf and Weng (2013a)
Comparability	The extent to which data holdings are consistent over time and use standard conventions, making them similar to other data holdings	CIHI (2009)
Plausibility	The element in the EHR makes sense in the light of other knowledge the element is measuring	Weiskopf and Weng (2013a)
Timely	Data is collected within a reasonably agreed timeframe after the clinical event and is available when and as often as required.	HIQA (2012b)
Currency	The EHR is a relevant representation of the person's state at a given point in time.	Weiskopf and Weng (2013a)
Validity	Data is collected in accordance within the rules or definitions applicable to that particular data.	HIQA (2012b)
Usability	The ease to which data may be understood and accessed from a place of storage.	CIHI (2009)
Relevance	It meets the needs of the information users.	HIQA (2012b)

To demonstrate the level of overlap and level of variability in data quality terms, Weiskopf and Weng (2013a) mapped data quality terms to five data dimensions (Table 3). The data quality term "accuracy" best demonstrates the degree of overlap between dimensions. As shown in table 3, there is no agreement on the abstract definition of accuracy, as it can be a synonym for completeness, correctness and plausibility. Accuracy is used both as a quality term and a dimension, with a number of studies using correctness and

completeness to measure accuracy (Wagner and Hogan 1996; Weiskopf et al 2013b; Mikkelsen and Aasly 2005). A literature review by Chan et al. (2010), agreed that few studies of data accuracy examined the same data elements.

Table 3: Common Dimensions of Data Quality and Terms (Weiskopf and Weng 2013a)

Five Dimensions of Data Quality				
Completeness	**Correctness**	**Concordance**	**Plausibility**	**Currency**
Accessibility	Accuracy	Agreement	Accuracy	Timeliness
Accuracy	Errors	Consistency	Believability	Recency
Availability	Misleading	Reliability	Trustworthiness	
Missingness	Corrections Made	Variation	Validity	
Omission	Positive Predictive value			

Completeness is widely associated with data availability or missing data (Weiskopf and Weng 2013a). Weiskopf et al. (2013b) suggests that completeness of EHR data should not be restricted to recorded or documented clinical observations. Instead, completeness should encompasses the breadth, density and predictability of the dataset and how well the available data matches the specific task at hand.

The concept of concordance also has a number of connotations, but agreement and consistency were the most frequently measured elements within this category (Weiskopf, and Weng 2013a). Definitions by Weiskopf and Weng (2013a) and CIHI (2009) show that concordance and comparability have similar meanings, with consistency between data holdings measured the most frequent.

The main time related dimensions proposed in the literature are currency, timeliness and recency. 'Currency' measures the quality of data entry time or the patient's state at a desired time of interest (Weiskopf and Weng 2013a). Typically currency and timeliness often refer to the same concept (Batini et al 2009).

Weiskopf and Weng (2013a) consider correctness, completeness and currency as the most fundamental quality data dimensions for research purposes. Whereas, plausibility and concordance were considered methodological approaches to assessing data quality. Completeness is the most commonly assessed quality dimension found across studies,

followed by correctness (Weiskopf and Weng 2013a). Chan et al (2010) found that data comparability was not widely studied and timeliness was the least studied dimension.

Clearly from the literature reviewed there is no consensus on a rigorously defined set of data dimensions or associated definitions. There is a great need for a consistent taxonomy of data quality to increase the reliability and consistency of data quality research (Weiskopf and Weng 2013a, Chan et al. 2010). Methodological weakness is another area found to impede research investigation into data quality. This is reviewed in the next section.

2.11.2 Research Methods

A generalizable approach to conducting data quality research is notably lacking. This makes it difficult to assess the levels of data quality in healthcare and renders meta-analysis unfeasible (Hogan and Wagner 1997; Weiskopf and Weng 2013a; Rabinovich and Cheon 2011; Chan et al 2010). An earlier literature review by Hogan and Wagner (1997) showed that a number of studies reported only one measure of accuracy and the gold standard set was inadequate to assess data quality. A more recent review by Weiskopf and Weng (2013a), show that as little as 39% of studies met the gold standard. The gold standard is defined as "*a dataset drawn from another source or multiple sources with or without information from the EHR*" (e.g. the paper record cross referenced with the EHR; patient interview or observation) (Weiskopf and Weng 2013a).

The literature also lacks statistically sound methods of measuring data quality according to (Weiskopf and Wang 2013a). Faulconer and de Lusignan's (2004) study was one of the few exceptions. This eight-step appraisal method uses statistical measurement to test completeness, accuracy, consistency and currency of chronic obstructive pulmonary disease (COPD) clinical coding. This is concerning, as poor rigour leads to high variability across studies and an inability to measure study reliability (Hogan and Wagner 1997; Chan et al 2010; Weiskopf and Weng 2013a; Cruz-Correia et al 2013). This needs to be addressed in future studies. The next section outlines a series of methods to improve data quality.

2.12 Data Quality Improvement Measures

The following section outlines a series of methods found to improve data quality. The first three sections look at the data entry improvement and the remaining sections look at a number of technological solutions.

2.12.1 Education and Training

A number of studies have shown that data quality can be improved through educational interventions (Ayoub et al 2007; Tolar et al 2012; de Lusignan et al 2004). A study by de Lusignan et al (2004) involving over 80 General Practices, showed that education intervention increased the data recording skills and knowledge of primary care professionals. Similarly, Ayoub et al (2007) found that training and education improved the recording of paediatric cancer amongst data managers. According to Tolar and Balka (2012) staff training and in-house technical support are essential when cultivating data for secondary use

According to Mikkelsen and Aasly (2005), data entered in the EPR system is more likely to be of high quality when it is considered important to the user. It is vital that users are educated on the significance of the data and not just within the confines of clinical use. Data quality is also likely to improve if users have confidence and skill in using the computer system (Craswell et al 2013). In the Australian Nursing and Midwifery Council, ICT competencies are embedded in nursing standards (Craswell et al 2013), demonstrating a national drive and commitment to improve data quality.

2.12.2 Motivational Interventions

Motivational interventions are found to enhance HCPs data entry (Morrison et al 2013; Hahn et al 2013; Barrie and Marsh 1992). Morrison et al. (2013) describe 11 strategies to repurpose clinical information system data for secondary use. Seven of the eleven strategies focused on motivating data entry through reducing it or making it more relevant to care. These included automation, workflow redesign, promoting data benefits, and senior leadership championing the data entry. Four other strategies address the machine readability of data. A combination of technical, individual and organizational aspects are needed to generate high data quality and to promote a culture of information usage (Morrison et al. 2013). Similarly, Hogan and Wagner (1997) suggest that errors may be introduced at many points in the process of data capture, thus it is insufficient to implement a single intervention to improve data quality.

2.12.3 Performance Monitoring

There is ample evidence to show that KPIs play an important role in monitoring and improving clinical practice (Bridgewater et al 2007; Francis 2010; HIQA 2013b, Whitty and

Crump 2005; Epstein 2006) and healthcare finance (Ireland et al 2011; Shorrosh 2011; Wadsworth et al 2009).

The success of performance monitoring is demonstrated in the literature (Van Der Meijden et al 2003; Sinclair and Zari 2000; Harrington et al 2009; Berler et al 2005). According to Shorrosh (2011), KPIs can help increase registration accuracy and thus increase revenue. In Shorrosh's study, metrics lead to a reduction in rework. Those implementing the KPIs learnt from the errors made and improved their practices because of on-going feedback on performance (Shorrosh 2011). In the UK, Coronary Artery Bypass Graft (CABG) surgery mortality was published to help drive improvements (Bridgewater et al. 2007). The findings showed a significant reduction in crude and risk adjusted mortality since the introduction of public disclosure, with no rejection of high risk cases coming to surgery. KPIs are also held in regard for monitoring performance in the theatre setting, as outlined in a number of studies and reports (RCSI 2013; Pandit et al 2012; Faiz et al 2008). They feature frequently in the Theatre Performance in Operating Theatre (TPOT) project as an aid to target efficiencies and improve patient outcomes (HSE 2014).

Performance monitoring has also been used to highlight high levels of mortality and poor practice in Mid-Staffordshire as outlined in the Francis Report (Francis 2010). The "Better Metrics" project is another good example of clinical performance measures which are relevant to clinician's day-to-day practice (Whitty and Crump 2005; Haslam 2007).

KPIs can also be used to encourage and motivate data quality performance (Sinclair and Zairi 2000). It is only through measurement that we can be sure that improvements are being made (HIQA 2013b). According to Wadsworth et al (2009), "*providing managers and staff with accurate, intuitive and easy to interpret data is one-third of the recipe for improvement*".

2.12.4 Technological Interventions

The literature shows a number of technological interventions that can improve data accuracy. Natural Language Processing (NLP) is used to search free text in electronic records, with added functionality such as automatic spelling correction and acronym ambiguity resolution (correct the meaning of an abbreviation based on the context (Pakhomov et al 2008). NLP holds promise, however, it has not reached the point where free-text can be transformed into "coded clinical data" (de Lusignan and van Weel 2006).

Data Quality probes (DQP) are useful in illustrating the trends in data quality and provide prompts for promoting and maintaining data quality (Brown and Warmington 2003; Faulconer and de Lusignan 2004). DQP involve the posing of a query in a clinical information system and generating a result based on the association between one data item and another. The system is limited, as a drug or a test result associated with a diagnosis is required.

Data modelling can play an important role in improving data quality. Sammon et al (2009) developed a prototype Patient Data Analysis Information System (PDA-IS) for Consultant physicians in Geriatric Medicine in Ireland. The PDA-IS facilitated the collection and storage of data, identified incomplete patient records, generated standards and facilitated analytical queries (SQL statement generated) on patient data. De Lusignan et al (2010) used algorithms as a search tool to help identify errors and omissions in the coding of Diabetes. The findings show that a simple structured searches, conducted regularly, could improve data quality and help flag cases for review.

Clinical Decision Support (CDS) can improve the accuracy of electronic data, particularly in relation to medication prescribing behaviour. CDS is a written application fed into a system that helps clinicians identify options for a treatment plan, a diagnosis or symptom specific guidance (Wilson and McEvoy 2012). Studies have shown that CDS can help improve the quality and accuracy of prescribing documentation (Galanter et al 2010; Kuperman et al 2007; Schedlbauer et al 2009). Computerised Physician Order Entry (CPOE) (a process of entering medications) with the addition of CDS has been shown to improve medication safety, due to improved communication and levels of accuracy and is more legible than hand written prescription (Schedlbauer et al 2009; Kuperman et al 2007).

2.12.5 Coding and Terminology Standards

HIQA recommends the widespread adoption of classification and terminology standards to enable information to be shared electronically, for aggregation of health-related data and ultimately to bring about good quality timely information (HIQA 2013c).

In the USA, The Strategic Health Information Technology Advanced Research Project (SHARPn) project was set up in 2010 to address the transformation of HI into standards driven infrastructure for secondary use of EHR data (Rea et al 2012). In the UK, the Health and Social Care Information Centre is driving the agenda for improving clinical coding, data

linkages between clinical terms and codes in order to obtain high quality hospital statistics (Spencer 2012). Under the term standards, the benefits of clinical coding and terminology standards will be discussed as means to improving data quality.

2.12.5.1 Clinical Coding

Roukema et al 2006 showed that structured data entry and clinical coding can improve data quality, particularly in relation to completeness and uniformity in reporting. Clinical coding is a process by which patient diagnosis and treatment is translated into standard recognised codes to ensure a consistent format and level of detail for describing procedure or diagnosis (HIQA 2013c; Wilson and McEvoy 2012). One of the best known coding systems is International Classification of Disease (ICD). In Ireland, the ICD version 10 and Related Health Problems (ICD-10-AM) is used to code clinical activity in hospitals.

Diligence in coding procedures can lead to high levels of data quality data and allows comparative measures of performance (Knight et al 2013; HIQA 2013d). Knight et al's (2013) investigated the coding completeness and internal consistency of 629,049 singleton birth delivery across 151 UK NHS trusts. The findings demonstrate high levels of maternity data completeness and consistency. This allows comparative measures of performance across NHS trusts and the construction of national maternity statistics. The uptake of clinical coding has increased. The UK Care Quality Commission states that the coding of primary diagnosis in hospital statistics has improved in accuracy from 73.8% to 96%, since the year 2002 (Care Quality Commission 2012).

2.12.5.2 Terminology Standards

Classification systems, such as ICD 10, are not designed or intended to document clinical care (HIQA 2013c). Alternatively, Systematised Nomenclature of Medicine-Clinical Terms (SNOMED CT) is a clinical terminology system designed to support the effective input of clinical data. SNOMED CT is a collection of medical terms providing codes, terms, synonyms and definitions that help encode the meanings of healthcare information. This system leads to greater quality of patient care due to improved clinical recording and greater transferability of clinical information within and across healthcare settings (HIQA, 2013c; Benson 2009). Both classification and terminology systems use standardised definitions and form a common medical language within the EHR. SNOMED CT supports information entry of the patient's care, while ICD facilitates information retrieval.

HIQA's (2013c) report "*Guidance on Classification and Terminology Standards for Ireland*" suggests that the full benefits of clinical terminologies are realised when they are linked and integrated with clinical classification for the purpose of generating data for secondary use (HIQA 2013c). Figure 4, shows how terminology systems such as SNOMED CT and LOINC (facilitates the exchange of laboratory test results) operationally sit between documents and classification systems such as ICD and the Office of Population, Censuses and Surveys Classification of Surgical Operations and Procedures (OPCS) which is used to capture surgical activity.

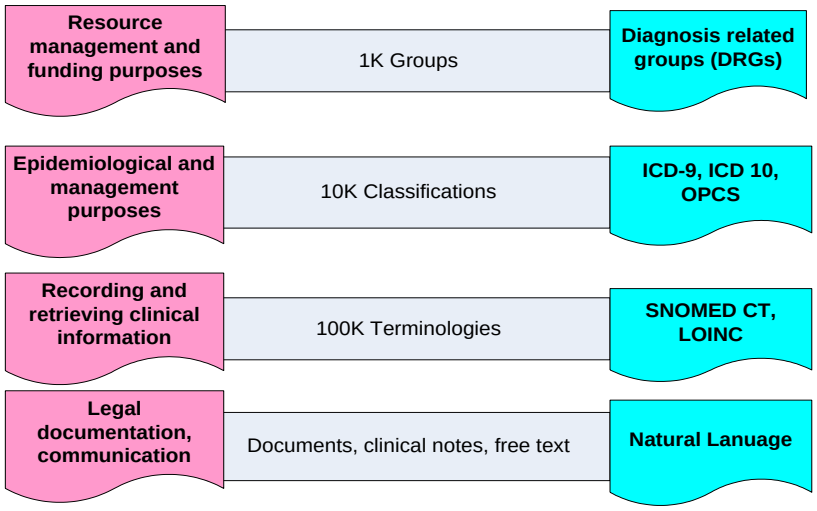

Figure 4: Clinical Coding System (HIQA 2013c)

Diagnostic related groups (DRGs) are a classification system used along with the existing HIPE system to capture episodes of care for case-based payments (DoH 2013b). All systems have a commonality in supporting better patient care and outcomes by improving data quality.

2.13 Conclusion

This review gave an in-depth analysis of the many facets to secondary use of data and data quality. The background previewed the importance of secondary use of data, data quality improvement and some of the current challenges faced by ICT and healthcare. Secondary use of data was reviewed within the Irish context, its value and benefits and the legal and patient protection considerations. Data quality was reviewed in terms of importance, the impact of poor data quality and some of the challenges to achieve data quality such as poor definition, unsatisfactory methodological approaches and competing clinical priorities.

The potential for secondary use of data to influence data quality is great. Secondary data is widely used for performance monitoring and the development of KPIs and metrics. The review has outlined a number of measures to improve data quality such as education, motivation and quality monitoring. Technical solutions to improve data quality related mainly to NLQ, DQP, CDS, clinical coding and terminology.

The literature review has outlined the benefits of secondary use of data and identified the gaps in data quality. The next chapter will outline the methods used to meet the study aims and objectives.

Chapter Three Methodology

3.1 Introduction to the Study Methods

The literature reviewed in Chapter 2 highlighted the gaps in relation to previous methodology, analysis and the importance of investigating secondary use of data as a means of improving data quality. From the literature review, the aim and objective of the study was developed. The study seeks to meet the following objectives;

1. To develop a methodology for the assessment of data quality.
2. To measure data completeness, concordance and timeliness pre and post quality interventions.
3. To identify significant gaps in data quality.
4. To identify the effectiveness of quality based strategies on improving electronic surgical data quality.

The methodology is described in terms of the research design, the study duration, sample, statistical analysis which will incorporate the hypothesis, and the ethical considerations. The study setting, the information technology system and the procedure to conduct the study are described. The researcher outlines a five step data quality process based on the principles of TDQM and research methodology. Data quality interventions based on secondary use of data are identified.

3.2 Research Design and Method

A pretest-posttest quasi-experimental design was used to investigate the effects of secondary use of data on data quality. (Figure 5). Quasi-experimental design has been widely used across a range of scientific disciplines, predominantly for comparing groups and/or measuring change results (Conry et al 2012). This design is also known to introduce minimum disruption in a natural setting (Parahoo 2006), which carries particular relevance for the operating theatre area.

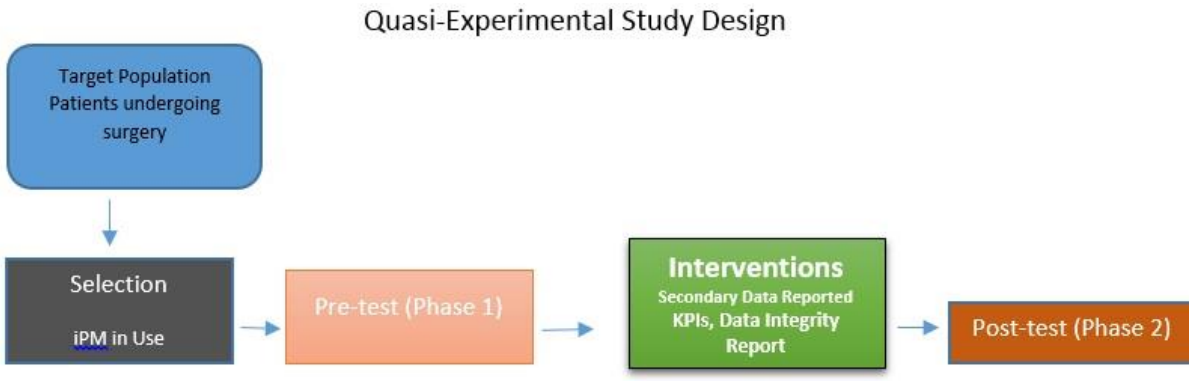

Figure 5: Quasi-Experimental Design (NCTI 2014)

While the study cannot be described as a true experiment, as subjects were not assigned to groups randomly (Parahoo 2006; Polit et al 2001), nonetheless, there was degree of research control. The type of surgery, operating theatre and theatre staff were unchanged between the pretest and posttest phases.

3.3 Study Duration

The study took place from January 8th to May 7th 2014. Data collection was based on three weeks information in January (phase 1) and a further three weeks in March (phase 2). Quality interventions were put in place during the month of February.

3.4 Sample

The study sample consisted of 148 patient entries over a two month period (70 entries in phase 1 and 78 in phase 2). This data sampling represents approximately 68% of monthly surgical activity for the operating theatre in question. The sample was random, consisting of those who underwent surgery during the study period. Data entry was over 24 hours, seven day basis and included all procedure types (elective, emergency, emergency in elective session). The next section outlines the statistical analysis used to compare pretest-posttest findings.

3.5 Statistical Analysis

Descriptive statistics was used to organise, interpret, summarise and present data quality for completeness, concordance and timeliness pretest-posttest. De Vaus (2001) recommends the use of descriptive statistics to measure the relationship between two or more sets of data. The surgical data was analysed using Microsoft Excel analysis tool-pack and illustrated in statistical tables, pie charts and side by side bar charts to show the

relationship between the two groups. The Standard Deviation (SD) was selected to identify the data field variability within the two samples and Z-tests were carried out to ascertain the statistical significance. A *p*-value of <0.05 was considered significant.

Hypothesis Testing

A hypothesis is a statistical procedure that is designed to test a claim (Rumsey, 2011). Hypothesis testing was carried out using four steps as follows;

1. The hypothesis was formulated.
2. An analysis plan made (level of significance and test method decided).
3. The data sample was analysed.
    a. Mean scores of samples obtained.
    b. Standard deviation calculated.
    c. Z-score computed.
    d. P-value was set.
4. The results were interpreted to confirm or deny the hypothesis.
   (This process was adopted from www.stattrek.com accessed 20/04/2014).

1. The hypothesis

Secondary use of data will lead to improvement in electronic data quality in the operating theatre.

The null hypothesis is H_o: $p_1 = p_2$

1. H_o: $p_1 = p_2$, where the mean of p_1 (pretest) and p_2 (posttest) is equal for completeness.
2. H_o: $p_1 = p_2$, where the mean of p_1 (pretest) and p_2 (posttest) is equal for concordance.
3. H_o: $p_1 = p_2$, where the mean of p_1 (pretest) and p_2 (posttest) is equal for timeliness.

The alternative hypothesis is Ha : $p_1 < p_2$

1. Ha:$p_1 < p_2$, where p_2 represents the proportion of the population that data completeness improved
2. Ha: $p_1 < p_2$, where p_2 represents the proportion of the population that data concordance improved

3. Ha: $p_1 < p_2$, where p_2 represents the proportion of the population that procedure confirmation timing improved.

2. Analysis plan and statistical test

The confidence level between the study samples was set at a 5% level of significance (2 SD=5%). This means the researcher will accept the results if they are statistically significant 95 times out of 100, which is acceptable for scientific research (Parahoo 2006). The *z*-test will be used to test the statistical difference between the means of two groups. This is appropriate with a sample size of greater than 30 (Rowntree 2000).

3. Data Sample Analyses

a The group means were calculated (pretest-posttest)

b The SD of the sample distribution was computed as follows;

- $\sigma_{p1 - p2} = \text{sqrt } [[P_1 * (1- P_1) / n_1]+ [P_2 * (1 - P_2) / n_2]]$

Where σ is the standard deviation of the sample portion, P_1 is the population proportion of sample 1, P_2 is the population proportion of sample 2, n_1 is the sample size from population 1 and n_2 is the sample size from population 2.

c As the sample mean and the SD were known, *z*-test was used to test the statistical significance.

$z = (p_1 – P_2) / \sigma$ where P_2 is the hypothesised value of the population proportion, p_1 is the sample proportion and σ is the standard deviation.

d The z score to *p* value was obtained using a published table calculator www.socsostatistics.com

e One-tail test was used to test the hypothesis

It was expected that the quality interventions would bring about data quality improvement, not simply differences. Therefore, one tailed test of significance was used, as this provides more power to detect an effect in one direction (Rowntree 2000). If the sampling distribution falls into one-end (tail) of the critical area as shown in figure 6, the alternative hypothesis will be accepted.

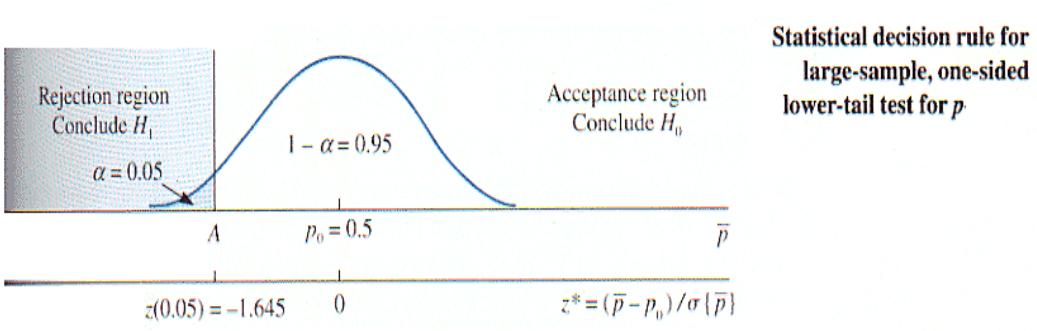

Figure 6: Distribution for a one tailed test (www.unc.edu exhibit figure 13.6)

4. Hypothesis Results

A statistic value was produced which determined the acceptance or rejection of the Null Hypothesis. The findings are discussed in 5.11.

Clinical research is necessary for the development of new knowledge, however inherent in this process is the need to ensure adherence to ethical standards (Steinke 2004). The next section will give an account of the steps taken to ensure ethical soundness and data confidentiality.

3.6 Ethical Considerations

Ethical approval for the study was sought and approved by the Clinical Research Ethics Committee at the study hospital and at TCD prior to the commencement of the study (Appendix 1.1). Patient consent was not required for the study as the data was anonymised (Data Protection Commissioner 2007; HIQA 2012a). Data was anonymised by removing identifiable information including the patient's name, Medical Record Number (MRN), the Consultant Surgeon's name, theatre name and hospital location before the analysis stage.

The greatest potential study risk was the identification of sensitive data relating to patient or clinicians. Measures were taken to ensure that patient information was appropriately and respectfully managed and was compliant with ethical considerations, laws and regulations. The actions taken are listed as follows;

- Data Protection (Amendment) Act 1988 and 2003 and HSE 2013 Guidelines were strictly adhered to at all stages of the study.
- The data was obtained and processed fairly, and kept safe and secure.

- Computer access to the study details were strictly limited and stored on an encrypted password protected computer.
- There was no identifiable data at the time of analysis and reporting.
- The data was used only for the purpose of the study and will not be retained for longer than the study requires.

In addition to ethical approval, permission to access the study data was obtained from key stakeholders. A hand delivered letter outlining the nature of the study was distributed to the following key stakeholders; the Information Services Manager, the Clinical Director of Surgery, relevant Surgeons, the Director of Nursing and Theatre Nurse Managers. The research was also enrolled with the hospital quality department. The researcher was requested to anonymise the identity of the study hospital. This request was adhered to in so far as possible. The following section outlines the study setting.

3.7 Study Setting

Data for the study was sourced from the operating theatre at a large teaching hospital in Ireland. Performing surgery is a complex process consisting of three phases; pre-operative (surgical preparation), inter-operative (in-theatre) and post-operative (recovery). The surgical interventions provided at the study hospital are highly specialised, complex activities that are undertaken in scheduled (planned) and unscheduled (unplanned) theatre time. The in-theatre service is delivered by highly skilled professionals including surgeons, anaesthetists, nurses and medical staff with various roles within surgery. These roles include surgeon, surgeon assistant, anaesthetist, anaesthetist assistant and several nursing roles such as theatre co-ordinator, anaesthetic nurse, scrub nurse and circulating nurse.

Record keeping is a necessary and critical part of surgical activity. In-theatre surgical data is concurrently recorded electronically in iSoft Patient Manager (iPM), and handwritten in a theatre log book. This task is undertaken by nurses and surgeons. The data recorded becomes part of the patient's medical history and is frequently used by physicians and nurses for audit and research purposes, with many other uses such as costing, billing and as a medicolegal reference.

Surgical data has been captured electronically in the study hospital since 2006 and in the study operating theatre since 2008. A theatre scheduling team was convened in 2012 to extend the theatre module usage to other operating theatres in the hospital. This

development was at mid-point at the time of the study. The electronic system will be described in the next section.

3.8 Information Technology System

iSoft Patient Manager (iPM), is used to capture patients surgical activity. This is a Patient Administration System (PAS), primarily used to support administrative, financial, in-patient and out-patient activity. The Theatre Manager module of iPM enables data capture at all stages of the patents surgical journey from scheduling the patient, pre-theatre and in-theatre activity to recovery timings (Figure 7).

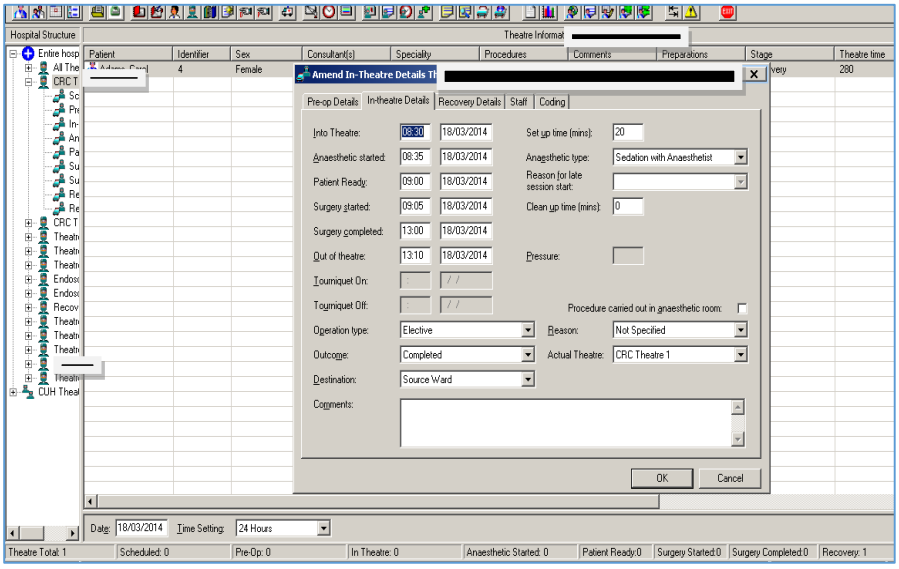

Figure 7: In-Theatre Screen (iPM System Train Master)

Data fields include surgical activity timings, the theatre staff present at surgery and the surgical procedure name, though it has other functionality as seen in figure 7.

The surgical procedural names are coded according to local codes which are pre-set within the system. These local codes are mapped to ICD-10 codes at the back end of the system. A brief overview of the process to schedule a patient for surgery (electronic and manual) is as follows;

- **Electronic**: Patient details and the planned procedure name is inputted at the time the surgery is scheduled. This is undertaken by administrative staff. In emergency cases (unscheduled), the procedure is entered by the theatre nursing staff ahead of the surgery.

- **Theatre Log**: The theatre nursing staff write in the procedure details (time in and out, procedure type) and the staff present at the time of surgery. The procedure(s) name is recorded on completion of the surgery. The patient demographical details are typically generated in label form from the electronic system.

Electronic data is captured by direct entry in structured fields within iPM. This is manually entered by clinicians (nurses and surgeons) at computer terminals within the operating theatre.

- Theatre nurses are responsible for recording the surgical and anaesthetic timings, staff present and any theatre delays.
- The surgeon is responsible for electronically confirming the surgical procedure carried out, the confirmation time and confirming/adding laterality.

Figure 8 shows the interface for confirming the surgical procedure code (refer also to training manual appendix 3.1)

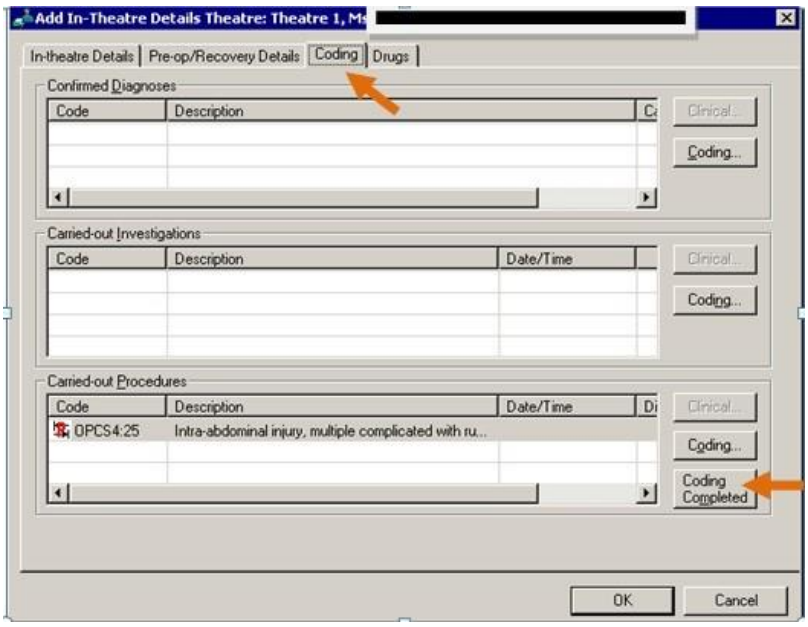

Figure 8: Confirming Surgical Procedure Coding (iPM System Train Master)

Laterality specification (left side/right side/anterior, posterior) is required for certain body parts and surgical procedures (e.g., surgical repair of right humerus fracture, left nephrectomy, and right cataract surgery). Failure to specify laterality can increase the incidence of wrong-site surgery (WHO 2009). Figure 9 shows the interface for capturing laterality (Appendix 3.1 and Appendix 6.1)

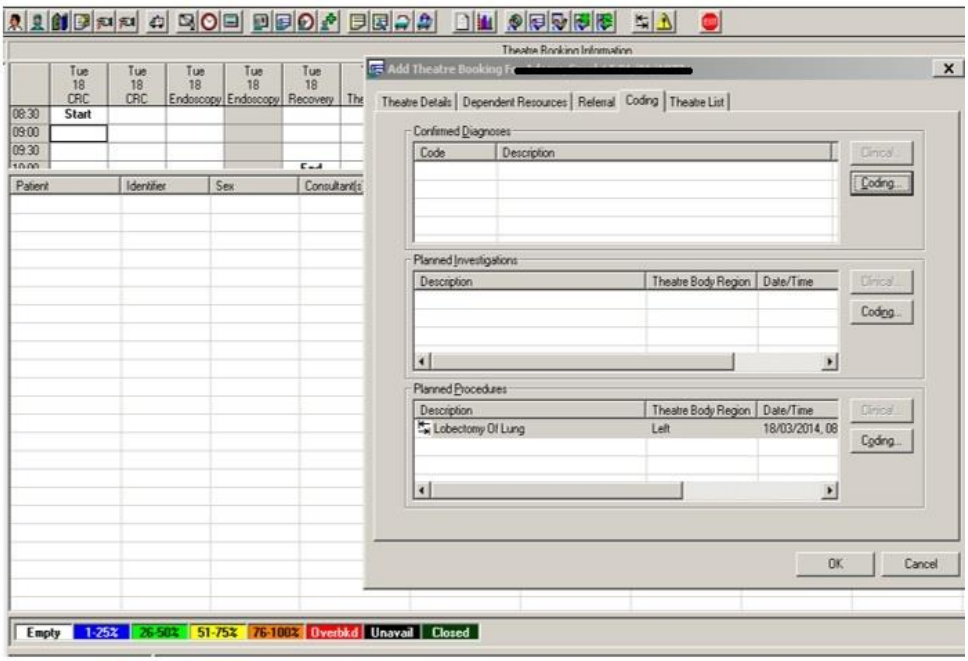

Figure 9: Laterality Specification (iPM System Train Master)

Confirming the surgical procedure code is a relatively new requirement. This function was activated and training provided approximately three months prior to the commencement of the study. Best practice guiding this system usage is governed by a local standard operating procedure (SOP). The SOP states that each surgical procedure should be confirmed following surgery and before the patient leaves the theatre. The next section discusses the procedure undertaken to evaluate data quality.

3.9 Procedure

The data in this study is based on the inter-operative surgical phase, also known as the in-theatre activity. The data requirements were determined by the researcher, table 4, and extracted from the iPM system by the IT Project Manager. This extraction and preparation process is outlined in figure 10. The data fields were imported into a bespoke Microsoft Excel spreadsheet, cleaned by removing duplicates and non-applicable material and organised into sections.

Table 4: Data Field Extraction

Electronic Surgical Record Data Fields																	
	Administration							Procedure							Team		
			Patients Name														
DATA Fields	1. Operative Description	2. MRN	3. Forename	4. Surname	5. Date of Birth	6. Speciality	7. Theatre Name	8. Date of Surgery	9. Procedure(s) Name	10. Into theatre time	11. Surgery Start Time (dttm)	12. Surgery Complete (dttm)	13. Out of Theatre (dttm)	14. Procedure Confirmed	15. Consultant Name	16. Theatre Staff Name	17. Role Description
LOCATION IN iPM	In-theatre Details	Patient Details Screen				Theatre Manager Screen				In-Theatre Details				Coding In-theatre tab	Theatre Manager Screen	Staff In-theatre Tab	Staff In-theatre Tab

Table 4 shows the data fields identified, number 1 to 17, and their mapped location on iPM.

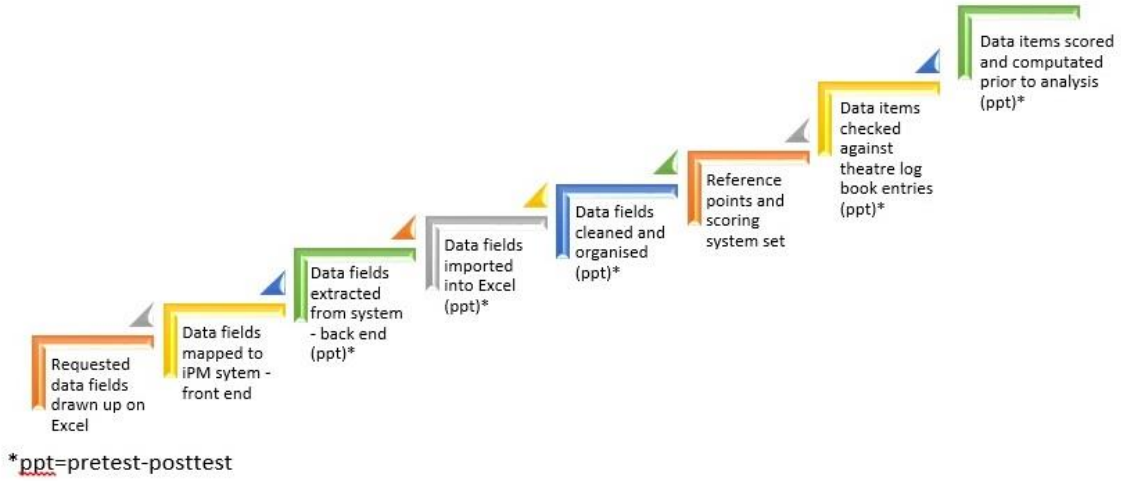

Figure 10: Data Extraction and Preparation Process

The collections of pretest-posttest data was validated against the theatre log book to establish the levels of completeness and concordance. This was carried out by two people, the researcher and a work colleague, to ensure greater accuracy of data collection. Surgical procedure concordance was also validated by theatre staff, as the researcher was not familiar with some of the surgical terms.

The theatre log book was identified as the Gold Standard and assumed to be correct. The theatre log is considered to be the official version of the patient record. Setting a gold standard is important as this reflects the true state of the patient in so far as possible (Weiskopf and Weng 2013a; Hogan and Wagner 1997).

Each data item was scored by the researcher, using a predefined scoring system as outlined in section 3.10.3. The allocated scoring was reviewed by two nursing colleagues who were familiar with surgical terminology. The data from phase 1 was used to inform the quality interventions, and was feedback to clinicians using TDQA techniques. Pretest-posttest analysis were undertaken and recommendations made for future practice. The next section provides the data quality methodology used to assess and improve the overall quality of data.

3.10 Instrument development

The instrument was based on the seminal works of (Weiskopf et al 2013b) measurement of completeness and Wang's (1998) TDQM framework, with reference also to other quality

based literature (Harrington et al 2009; Batini et al 2009; Pipino et al 2002; Parsley and Corrigan 2002; Wang 1998). As a result, an eight step data quality process was developed, which met a main objective of the study. This sequence is outlined as follows,

1. Select the data fields pertinent to the study (3.10.1).
2. Outline the data dimensions to be measured (3.10.2).
3. Devise a scoring system (3.10.3).
4. Define the data quality requirements (3.10.4).
5. Pilot the instrument (3.10.5)
6. Develop quality interventions (3.11).
7. Measure the results (Chapter 4).
8. Implement the quality interventions and measure once again (chapter 4, 5)

3.10.1 Data Field Selection

The surgical data field selection was based upon information currently collated in the theatre log with additional timing fields pertinent to surgery. The electronic surgical record is a complex structure. At the most basic level, it comprises of data fields, data items and data sets. For the purpose of this research, the following definitions apply;

- A data field is a component of the surgical record which is used to store data.
- Data fields can be combined to form a data set. A data set is defined as "*a set of data collected for a specific purpose*" (HIQA, 2013b). Three data sets were identified to measure data quality; completeness, concordance and timeliness (Table 5).
- The data fields can be assessed individually or as part of the entire surgical record i.e., also referred to as orthogonal (intersecting or at right angles) (Weiskopf et al 2013b)
- Data fields are made up of individual data items. These contain values which can be computed in different ways, with different uses.
- A summation of data items can be performed and subsequently the occurrence (rate) of data items can be displayed.

The aforementioned data sets reflects the surgical activity captured in the theatre log book. Four exceptions apply;

1. There are additional surgical timings which are not captured in the theatre log book (surgery start and complete time).
2. Surgical procedure name and laterality are one of the same field in the theatre log book. For analysis purposes these were divided into two separate fields
3. Surgical procedure code confirmed is not a data field in the theatre log book.
4. The timeliness of confirming the surgical procedure code was based on iPM data only, as the necessary time points were not available in the theatre log book

Table 5, models the three data sets in the study. At the outset, surgical data fields were categorised under administrative, procedural and team domains for reporting purposes. 5.1 shows there are 18 data fields for completeness (Figure 5.1), 15 for concordance (Figure 5.2) and 1 single timing data field (Figure 5.3).

5.1 Concordance Data Fields

Administrative Data							Procedure					Team		
		Patients Name												
1. Operative Description	2. MRN	3. Forename	4. Surname	5. Date of Birth	6. Speciality	7. Theatre Name	8. Date of Surgery	9. Into Theatre	10. Surgical Procedure	11. Laterality of Surgical	12. Out of Theatre	13. Consultant Name	14. Staff Present	15. Role Description

5.2 Completeness Data Fields

Administrative Data							Procedure								Team		
		Patients Name															
1. Operative Description	2. MRN	3. Forename	4. Surname	5. Date of Birth	6. Speciality	7. Theatre Name	8. Date of Surgery	9. Into Theatre	10. Surgery Start	11. Surgery Complete	12. Surgical Procedure Name	13. Laterality of Surgical Procedure	14. Surgical Procedure Code Confirmed	15. Out of Theatre (hr:min)	16. Consultant Name	17. Staff Present	18. Role Description

5.3 Timeliness Data Field

Procedure
1. Surgical Procedure Code Confirmation

Table 5: Surgical Data Sets

3.10.2 Quality Dimension Selection

Following an in-depth analysis of data measures, the researcher decided the quality dimensions completeness, concordance and timeliness were the most appropriate for the study context, the data available and the available time-frame. For the purpose of this study, the following definitions apply;

Completeness: "*Data that has all the items required to measure the intended activity or event*" (HIQA 2012b).

Concordance: "*Agreement between elements in the EHR, or between the EHR and another data source*" (Weiskopf and Weng 2013a).

Timeliness: "*Data is collected within a reasonably agreed timeframe after the clinical event" and is available when and as often as required*" (HIQA 2012b).

- **Completeness:** The surgical record was considered to be complete if the (a) breadth and (b). density were present (adapted from Weiskopf et al 2013b).
    a. *Breadth*: If the total eighteen items in the surgical record was present, And
    b. *Density*: Individual occurrences of the data items were present over the study period (70 records pretest and 78 posttest).
- **Concordance:** The surgical record was considered to have concordance if
    a. The surgical record information in iPM was consistent with the fifteen components in the theatre log book
- **Timeliness**: The procedure code confirmation was considered to be timely if
    a. the surgical procedure code was confirmed within the set timing rule.

3.10.3 Scoring System

A scoring system was devised to objectively measure the data dimensions and to meet the aim of the study. The scoring system is outlined in table 6 and computations are shown in section 3.10.3.1. Data quality dimension scores were measured to test the hypothesis, each record over 90% for completeness and concordance was measured to demonstrate the level of improvement in scores, and each data field was measured to demonstrate gaps in data quality. Several researchers recommend statistical measurement to improve data quality reporting (Hogan and Wagner 1997; AHRQ 2007; Weiskopf and Wang 2013a).

The data quality measurement was calculated using simple ratios based upon the work of Pipino et al. (2002). Pipino et al developed basic principles for assessing data quality in industry. Simple ratio is measured as the desired outcome calculated against total outcome. In this, 1 represents the most desirable and 0 the least desirable score. Trends are illustrated in positive terms, as this is preferable for showing trends of continuous improvement (Pipino et al 2002).

Four fields within the Procedures and Team domains required more than a single entry, therefore scores were expressed as a percentage of 1. This rule applied in the following instances;

- A surgical patient may have multiple procedures (surgical procedure name)
- The theatre staff present can range from a maximum of ten to a minimum of three (theatre staff present).

- There are a number of role descriptions within the surgical team as mentioned previously (role description).
- Surgical laterality may not apply to all procedures.

Table 6: Scoring System

Completeness Scores	
iPM data points are complete	A score of 1 is allocated
Exception data points are complete • Surgical Procedure Name • Theatre Staff Present • Role Description	$\frac{\textbf{Total correct entries in iPM}}{\textbf{Total entries in theatre log}}$ X1 Example: Maximum Score =1, Theatre Log = 5, iPM = 2 Score Allocated 2/5*1= 0.40
Laterality is applicable	A score of 1 is allocated or apportioned if multiple procedures apply.
Concordance Scores	
iPM field and theatre log book entries are in concordance	A score of 1 is allocated
Exception data points are in concordance • Surgical Procedure Name • Theatre Staff Present	$\frac{\textbf{Correct records on iPM}}{\textbf{Total Records (correct iPM and theatre)}}$ X1 Example: Maximum Score=1, Total Records = 11, Correct Records 7. Score Allocated. 7/11*1 = 0.64
Laterality is confirmed	A score of 1 is allocated or apportioned if multiple procedures apply.
Timeliness	
Procedure Code is confirmed	A score of 1 is allocated (refer to table 8 for timing rules)

3.10.3.1 Computation of Scores

1. The mean of each quality dimension, $\bar{x}$, was the sum, Σ , of the mean of each record, $\bar{x}$, divided by the number of records, n_i

   $$\bar{x} = \Sigma x_i / n_i$$

   a) This mean score for completeness was calculated as the sum of the mean of each 18 data fields, for concordance the sum of the mean of each 15 data fields and for timeliness it was a single data field. The formula was the same as that used above in 1

2. The mean of each data field, $\bar{x}$, was calculated as the sum, Σ, of all occurrences of the data items, x_i, divided by the number of occurrences, n_i

$$\bar{x} = \Sigma x_i / n_i$$

3. The mean for records between 90-100% complete, was the sum of records with means over 90%, divided by the number of records. The same calculation applied for concordance. The formula was the same as that used above in 2.
4. The mean laterality score, $\bar{x}$ was calculated as the sum of the times laterality was present, x_i, divided by the number of items, n_i, where laterality applied.

$$\bar{x} = \Sigma x_i / n_i$$

3.10.4 Requirements

The requirements to attain a maximum score are detailed in table 7 and table 8. Table 7 shows the requirements for completeness and concordance

Table 7: Data Fields and Requirements (Completeness and Concordance)

Surgical Data Fields	Data Dimensions	Requirements
1. Operative Description	Complete Concordance	Elective, Emergency, Emergency in an Elective session is recorded in iPM Operative description in iPM is the same as log book recording
2 MRN	Complete Concordance	Patient MRN is recorded in iPM MRN recorded in iPM is the same as log book recording
3,4. Patient's Name	Complete Concordance	Forename and surname is recorded in iPM Patients name recorded is the same as log book recording
5. Date of Birth	Complete Concordance	Date of birth in the format date month year (dttm) is recorded in iPM Date of birth recorded is the same as log book recording
6. Speciality	Complete Concordance	Surgical speciality is recorded in iPM Surgical speciality recording is the same as log book recording
7. Theatre Name	Complete Concordance	The theatre in which the surgery took place is recorded in iPM The theatre recorded in IPM is the same as log book recording
8. Date of Surgery	Complete Concordance	Date of surgery in the format date month year (dttm) is recorded in iPM The date of surgery recorded in iPM is the same as log book
9. Into Theatre	Complete Concordance	Date and time of "into theatre" is recorded in iPM A 10% (6min/60 mins) difference between iPM and theatre log is allowed for concordance.
10. Procedure Name	Complete Concordance	Name of procedure(s) is recorded in iPM. Procedure(s) name in iPM is the same as log book recording
11. Consultant Name	Complete Concordance	Primary consultant s name is recorded. Primary consultants name in iPM is the same as log book recording.
12. Theatre Staff Present	Complete Concordance	Names of theatre staff present at the surgery are recorded in iPM. Theatre staff recorded in iPM are the same as log book recording.
13. Role Description	Complete Concordance	Staff roles are recorded in iPM. Roles include surgeon, surgeon assistant, anaesthetist, anaesthetist assistant, scrub nurse, circulating nurse. Staff roles recorded in iPM are the same as log book recording
14. Surgery Start	Complete (iPM only)	Start Time (dttm) is recorded in iPM
15. Surgery Complete	Complete (iPM only)	End Time (dttm) is recorded in iPM
16. Out of Theatre	Complete Concordance	Out of theatre time (dttm) is recorded in iPM A 10% (6min/60 mins) difference between iPM and log book is allowed for concordance
17. Procedure Code Confirmed	Complete (iPM only)	The surgical procedure code is confirmed in iPM after surgery has started
18. Laterality	Complete Concordance	Procedures laterality (Left, Right, Bilateral) is specified in iPM. Procedure laterality specified in iPM is the same as log book recording
Data points are scored with a possible 1 or 0. Maximum completion score is 1, minimum score is 0. Selected electronic fields are measured for Completeness and Concordance against the theatre log book (Fields 1-13, 16,18). Surgical start and finish time is not recorded on the theatre log book.		

Table 8 sets out the requirements for timeliness. These are identified as follows;

- The time interval between the surgery completion and out of theatre was the timing rule set. Timeliness was measured against the surgical start, completion and out of theatre times on iPM.
- Half marks (0.50) were allocated for the following instances;

- If the procedure code was confirmed between out of theatre time and before the end of the surgical session.

  OR

- If completed in advance of surgery completion time (within 10% of overall operating time).

- A score of 0 was allocated if the procedure confirmation time was absent, exceeded the 10% rule, or was after theatre session time.

Table 8: Surgical Field and Requirements (Timeliness)

Surgical Data Point	Data Dimensions	Requirements
1. Surgical Procedure Confirmation Time	Timeliness (iPM Only)	The Surgical Procedure Code is confirmed between surgery complete and out of theatre time.
		a) Half marks (0.50) are allocated if the procedure code is confirmed before end of theatre session* Or
		b) If completed within 10% (of overall operating Theatre time) from surgery complete time.
Datapoints are scored with a maximum score of 1 and a minimum score of 0. Coding confirmation timing is verified against surgical timings; Start, End, Out of Theatre. *Theatre morning session end time : 13.00 Theatre afternoon session end time: 18.00		

3.10.5 Pilot

The scoring system was developed based on literature findings, discussions with the Information Service Manager and the research Supervisor. A number of sample procedures were piloted to assess the validity and reliability of the instrument prior to the main study and to identify weaknesses in the scoring system. According to Parahoo (2006), an instrument's validity is the degree to which it measures what it sets out to measure and reliability refers to the consistency of a particular method of measure i.e., if the same measure was applied would it generate the same answer when observing the same phenomena.

Following the pilot phase, two changes took place in the scoring requirements. These are detailed in the following sections.

Role Description

Two variances took place in relation to role description. The role of "anaesthetic nurse" and "theatre co-ordinator" was recorded in iPM but not in the theatre log book. On discussion with the research supervisor, the scoring requirements were adjusted to allow for this variance.

Laterality

Surgical procedures are typically recorded in a theatre log book according to the **procedure name** and the associated autonomy (e.g., **craniotomy** for removal of space occupying lesion (SOP). Initially, laterality requirements applied when they were included within the procedure name (e.g., **left craniotomy** for SOP), thus a score (1 or 0) was applied. If laterality was linked to the anatomy (e.g., craniotomy for **left SOP)**, laterality requirements were recorded as not applicable (NA).

On discussion with the research supervisor, a surgical procedure was considered to have laterality requirements if the procedure name or the associated anatomy were recorded as left, right, bilateral, posterior or anterior. The scoring requirements were adjusted to allow for this variance.

3.11 Quality Interventions

In fitting with TDQM improvement phase, a number of quality interventions (section 3.11.1 3.11.2, 3.11.3) were put in place by the researcher following the analysis of phase one. These quality interventions utilised secondary data from phase 1. An action chart was used to plot the study feedback as recommended by Galanter et al (2010).

The quality interventions were as follows;

1. Feedback to clinicians using a SWOT analysis framework
2. KPIs based upon pretest findings
3. A data integrity report to enhance data completeness.

These quality interventions will be detailed in chapter 4.

3.11.1 Feedback

Feedback of the pretest findings was presented within a SWOT analysis framework. SWOT analysis is seen as a top technique used to gain valuable organisational insights and to build a strategic framework (Ip and Koo 2004). The aim of using a SWOT analysis was to provide theatre staff with a balanced view of the strengths and weakness of the data quality.

All study findings with a score of 90% or greater was placed in the Strengths column, giving recognition for the good work carried out. Study findings with a score of less than 90% were presented in the weakness column. The opportunities section was used to highlight

potential areas for improvement and to specify the benefits of engagement. The threats section demonstrated the challenges to improving data quality.

3.11.2 Key Performance Indicators

KPIs were devised based upon findings from phase 1 of the study. Setting goals for improvement is central to TDQM philosophy and needs to begin as soon as the analysis phase is complete according to Wang (1998).

A set the clinical targets were identified for completeness, concordance and timeliness and for clinician IT linkage. The persons responsible for meeting the set targets and the date for achievement formed an important part of KPIs development.

3.11.3 Data Integrity Report

A data integrity report was used to enhance data completeness and reduce the manual effort of searching for missing values. Data integrity refers to the process of maintaining and assuring the accuracy and consistency of data over its entire life-cycle (Boritz 2011). These reports are frequently used in business intelligence to help identify missing data and facilitating accurate data capture (Pipino et al 2002; Boritz 2011). Generated through Crystal reports business intelligence application, this report automatically executes, compares and logs exceptions in iPM data. As a result, clinicians were able to generate the report in iPM and make the necessary changes to the data.

3.12 Conclusion

This chapter presented the research design and methodology for assessing data quality in the theatre setting. A pretest-posttest quantitative quasi-experimental design was identified as an appropriate research approach. Descriptive statistics will be used to organise, interpret, summarise and present the study data pretest and post-test. The null hypothesis and alternative hypostasis were set and *Z*-tests identified as the most appropriate measure of statistical significance. The value of significance was set at a p value of <0.05. The steps taken to ensure the study was in accordance with ethical and data protection requirements were identified. A detailed description was given of the study setting, the electronic system in use and the procedure undertaken to conduct the study.

The data dimensions completeness, concordance and timeliness were identified as the most suitable dimensions to measure in-theatre surgical data. An eight step data quality process was developed to facilitate the construction, measurement and improvement of data quality and meet one of the objectives of the study. This was based on TDQA, in conjunction with research methodology. The scoring system was piloted to increase validity. Quality interventions, namely KPIs and feedback of secondary use of data through SWOT analysis, was used to improve data quality ahead of phase 2 of the study. A data integrity report was also implemented to allow ongoing correction of incomplete data fields.

The next chapter presents the findings of the pretest results.

Chapter Four Quality Interventions

4.1 Introduction to Quality Interventions

Chapter 3 describes the methodological steps used to evaluate the impact of secondary use of data on data quality. This chapter presents the pretest findings and the KPIs developed in advance of the posttest phase. Pretest findings can be viewed in appendix 2 (Completeness 2.1, Concordance 2.2, and Timeliness 2.3).

4.2 Action Chart

A simple action chart (Table 9) was used to plan the study feedback and guide the necessary actions to enhance data quality. This was a useful tool, as it gives visibly to each action, the responsible person and the target date for completion as recommended by Galanter et al (2010).

Table 9: Action Card (Galanter et al, 2010)

Action Card Arising from Surgical Data Quality Analysis February 2014			
What Action			
1. Provide feedback from the study findings phase 1 to the following key stakeholders; a. Surgeons and their teams b. Clinical Director c. IT Health Information Manager d. IT Data Manager e. Clinical Nurse Managers f. TPOT Project Lead g. Nurse Trainer	Researcher	End of Phase 1. Week three February 2014	SWOT Analysis Report
2. Inform HIPE administrator of duplicate record	Researcher	On discovery	e-mail
3. Set KPIs.	Researcher and theatre nurse manager	Intervention phase - week four February 2014	The pretest study findings, phase 1
4. Put a process in place for timely IT medical staffing updates.	Anaesthetist Link Nurse	Week three February 2014	Meetings and feedback
5. Training manual update; specifically targeting surgical procedures confirmation and laterality specification.	Researcher	Week four February 2014	e-mail and electronic system
6. Data integrity report complete, checked, validated and access established.	ICT support analyst and Researcher	Week four February 2014	Crystal Reports, iPM

Action 1: A SWOT analysis of the study findings was presented to key stakeholders. This was communicated in-person and by e-mail.

Action 2: The duplicate MRN identified was reported immediately to the HIPE administrator.

Action 3: KPI were set ahead of phase 2 in conjunction with the theatre nurse manager.

Action 4: The researcher met with clinicians responsible for communicating staff changes, and a plan of action was put in place for the timely update of staffing on iPM. Any outstanding access applications were completed by staff and processed by IT personnel.

Action 5: The in-theatre training manual was updated (Appendix 3.1), specifically targeting instructions on confirming the surgical procedure, how to replace and/or add another procedure and add laterality.

Action 6: A data integrity report was developed as part of the theatre project, but not implemented up to the time of the study (Appendix 4.1). This report was tested by researcher and updates carried out by an IT analyst. Staff access rights were established to allow the ongoing correction of incomplete data fields.

4.2 Pretest Results

The findings of the pretest results showed a good rate of completeness (88%) and a moderate concordance rate (84%), based upon the measurement of 70 surgical records. The administration domain showed the greatest level of completeness (99% to 100%). This level reduced in the team domain, where there was a wide range of scores (79% to 97%) and further reduced in the procedural domain (26% to 100%). For concordance, the administration domain also scored the highest (81% to 99%), with a wide score range seen in the team domain score (72% to 90%) and a further reduction in procedural data (13% to 100%). This demonstrates large inconsistencies between the theatre log and iPM. The timeliness of surgical procedure code obtained a poor score (27%).

The pretest study findings was presented to clinicians in a SWOT analysis framework (Table 10, Appendix 2.1,2.2,2.3). The content of this framework is described in the following section.

4.2.1 Strengths

Administrative data featured strongly in the strengths column (Table 12, S1-10). All administration fields for completeness and six of the seven fields for concordance were presented as strengths. In this category, the concordance score for the theatre name (S14) was 93%, with five episodes of inconsistency between the theatre log book and iPM.

Emergency surgery performed outside the designated theatre was not captured electronically, suggesting the need for further system training. There was a 90% agreement in relation to the into theatre time (S16) and the primary consultant's name (S17), suggesting greater consistency is needed in these area. The procedure timings attained high scores for completeness (93% to 97%), however, no field attained a full completeness score of 100%.

Table 10: SWOT Analysis Pretest

Surgical Data Quality Analysis (Study Findings Phase 1)					
		Strengths			**Weakness**
Completeness		Completeness Scores	Completeness		Completeness Scores
		Administration Data			Administration data
	S1	Operative Description = 99%		W1	One patient was found to have two MRNs
	S2	Demographic Data: Patient Name, MRN, Date of Birth = 100%			Procedural Data
	S3	Theatre Speciality and Theatre Name = 100%		W2	Laterality of Surgical Procedure = 26%
		Procedural Data		W3	Surgical Procedure Code Confirmed = 46%
	S4	Date of Surgery = 100%			Team Data
	S5	Into Theatre field = 97%		W4	Theatre Staff Present = 79%
	S6	Surgical Start field = 94%		W5	Role Description = 79%
	S7	Surgical Complete field = 93%			
	S8	Surgical Procedure Name = 92%	Concordance		Concordance Scores
	S9	Out of Theatre field = 94%			Administration Data
		Team Data		W6	Operative Description = 81%
	S10	Consultant Name = 97%			Procedural Data
Concordance				W7	Surgical Procedure Name = 82%
		Concordance Scores		W8	Laterality of Surgical Procedures = 13%
		Administration Data		W9	Out of theatre field = 69%
	S11	Demographic Data: Patient Name, Date of Birth =99%			Team Data
	S12	Speciality = 99%		W10	Theatre Staff Present = 72%
	S13	Medical Record Number (MRN) = 97%		W11	Role Description = 77%
	S14	Theatre Name = 93%			
		Procedural Data			
	S15	Date of Surgery = 100%	Timely		Timely
	S16	Into Theatre Time field = 90%		W12	Surgical Procedure Code Confirmation Time = 27%
		Team Data			
	S17	Consultant Name = 90%			
Timely					
		Timely			
		Refer to W12			
		Opportunities			**Threats**
	O1	Greater data quality results in trust and confidence in the data		T1	Busy environment with conflicting priorities
	O2	Revenue gains due to accurate recording of procedures		T2	Difficulty gaining cooperation from all key stakeholders
	O3	The availability of a data integrity report to support the process		T3	Taking ownership for data quality
	O4	Surgical Team Involvement		T4	Maintaining standards can be challenging
	O5	Better quality reports due to improved surgical data		T5	Dual recording (electronic and log book) of surgical data is time consuming & may increase errors
	O6	Data can be monitored using predefined statistical analysis		T6	High clinical staff turnover requiring frequent & ongoing updates between clinicians and IT staff
	O7	KPIs to support ongoing data quality improvement		T7	Lack for medical administration staff leading to delays in informing IT of updates
	O8	Long term opportunity to remove the theatre log book		T8	Role out of electronic system across theatres is an orgisational priority.
	O9	Role out of electronic system across theatres is an orgisational priority		T9	Surgical data quality is a separate workstream with no formalised links to T8
	GLOSSARY OF TERMS				
	Administration Data: Operative Description, Patient Name, MRN, DOB, Speciality, Theatre Name				
	Procedural Data: Date of Surgery, Procedure Name, Laterality, Surgical Procedure Code Confirmed, Surgical Procedure Timings (Into theatre, Out of Theatre, Surgery Start and Complete)				
	Team: Consultant Name, Staff Present, Role Descriptions				
	Completeness: Data that has all the items required to measure the intended activity				
	Concordance: Agreement between elements in the electronic record and another data source (theatre log book)				
	Timeliness: Data is available within a reasonable agreed timeframe after the clinical event (confirming the surgical procedure)				
	Calculations: Simple ratio is used to calculate study fields. Data fields are scored individually with a maximum score of 1 and a minimum score of 0. Total field scores are calculated and divided by maximum score (1). For concordance, the theatre log book is identified as the gold standard and iPM measured and scored against this data.				

4.2.2 Weakness

The study findings with a score of less than 90% were presented as weaknesses (Table 10, W1-12), and highlighted the gaps in data quality. The greatest gaps were found in the procedural and team domains. These selected fields showed parallel weakness for both

completeness and concordance measures. For timeliness (W12), just over one quarter of surgical procedures where confirmed within the time rule (27%), suggesting much room for improvement.

Of the procedures where laterality applied (n=46), just over one quarter were completed (26%) (W2) reducing to over one tenth (13%) for concordance (W8). The low incidence of laterality confirmation was addressed by updating the training manuals, providing feedback to key stakeholders and setting KPIs (Table 9, Actions 1,3,5).

The concordance of the operative description was 81% (W6). This field is important for reporting purposes, as it identifies elective versus emergency procedures. This score was addressed through feedback and setting KPI (Table 9, Action 1, 3).

The concordance score of surgical procedure name was 82% (W7). The inconsistencies shown in this field was in part due to incomplete coding lists and secondly, just under half of surgical procedure codes were confirmed (46%, n=70) (W3). Surgical procedure coding confirmation time obtained a weak score as previously mentioned (W12). The mapping of local procedure codes to ICD10 codes is still in its infancy, with ongoing work continuing in this area. The low incidence of surgical name and procedures code confirmation was addressed through key stakeholder feedback, updating training manuals, the introduction of a data integrity report and setting KPIs (Table 9, Actions 1, 3, 5, 6).

The presence of theatre staff scored 79% for completeness (W4) and 72% for concordance (W10). A number of names were not included in the system staff pick-list, hence the low score for completeness and concordance. Similarly, the role description field attained a poor score of 79% for completeness (W5), reducing to 77% for concordance (W11). Managers need to ensure that all relevant personnel have access to the system and are named within the electronic staff listings. There is a requirement for clinicians to have stronger links with the IT department to ensure greater accuracy of this information. Study feedback, updating the process for IT linkage and setting KPI were the methods used to address these gaps (Table 9, Actions 1, 4).

The out of theatre time field (W9) attained a poor score of 69% for concordance, but was found to be 94% completed (S9) in iPM. This is an area where improvement could be achieved, as a large number of “out of theatre” times were not recorded in the theatre log

book. The level of inconsistency between the log book and iPM was addressed by providing the study feedback to nurse managers and setting KPI targets (Table 9, Actions 1,3).

4.2.3 Opportunities

The opportunities section of the SWOT analysis highlight nine areas where improvements in data quality and engagement in quality measures may benefit the operating theatre (Table 10, O1-O9). The opportunities focus on what is thought to be important to clinicians, such as being able to trust the data and the increase the revenue accrued from more accurate data recording (O1,O2) (DoH 2013b; RCSI 2013). Clinician's level of engagement and the value they assign to information is critical to ongoing data improvement (Mikkelsen and Aasly 2005; Morrison et al 2013). Also, as highlighted extensively in the literature review, decision makers depend on quality data for effective delivery of services (HIQA 2013a).

This study provides an opportunity to improve data completeness due to the availability of a data integrity report (O3). This should result in better data for report purposes (O5). The data dimensions measured and the assessment tool developed can be used for ongoing monitoring purposes (O6). Ultimately, improving data quality may pave the way for removing the theatre log book, thereby eliminating the need for dual recording (O8). Good quality data (O1), team involvement (O4) and the ability to measure observable goals (O7) are key components for an outcomes focused healthcare organisation (HIMSS 2006).

4.2.4 Threats

The threats outlined in the SWOT analysis framework show the challenges to improving data quality (Table 10, T1-9). Competing priorities (T1), poor level of clinician engagement (T2) and reluctance to take ownership for data quality (T3) are well-known and much researched phenomena in IT literature (Helms et al 2008; Berler et al 2005; Spencer et al 2012). Situations such as a high clinical turnover of staff (T6), lack of administrative support staff (T7), operating within tight budgets and stretched resources reflect the clinical realities of the healthcare environment (Sammon et al 2009). These realities can have an adverse impact on data quality (AHRQ 2007; Berler et al 2005). While maintaining standards, and ensuring correct up-to-date system information is challenging (T4), this is nevertheless necessary if good quality data is to be available to clinicians. The dual recording of surgical information in the log book and iPM is also identified as a threat, as it

adds pressure to workflow and allows for greater margins of recording error (T5) (Mikkelsen and Aasly 2001; Stausberg et al 2003).

The role out of the electronic system was identified as both an opportunity and a barrier (O9, T8) to measuring data quality. The positive effects included the focus on ICT, its capabilities in supporting clinicians work and new learning. Conversely, there was concern that measuring data quality at this time may be seen as a de-motivator. According to Van Der Meijden et al (2003), the timing of an evaluation is important. It was decided that measuring data quality should be a separate work steam requiring a new project team going forward (T9).

4.3 Key Performance Indicators

The purpose of the KPIs was to motivate improvement data entry performance. The KPIs were developed (Table 11) based on the study findings and the view of the nurse manager. The persons responsible for ensuring the targets are met and the date for review was also identified in line with HIQAs recommendations for KPI development (HIQA, 2013b).

Table 11: KPIs Pretest

Surgical Data Key Performance Indicators Pretest			
DATA QUALITY DIMENSIONS	**TARGETS**	**PERSON RESPONSIBLE**	**DATE**
Completeness Electronic Record	**Procedure**		
	Surgical Procedure Name will have a completion rate of 95%	Consultant/Surgeon	End of Q1*
	Surgical Procedure Code Confirmation will be complete in 80% of instances	Consultant/Surgeon	End of Q4*
	Laterality of Surgical Procedures will be 80% completed	Consultant/Surgeon	End of Q1
	Surgery Start Time will be 95% complete	Nursing	End of Q1
	Surgery End Time will be 95% complete	Nursing	End of Q1
	Out of theatre will be 95% complete	Nursing	End of Q1
	Team		End of Q1
	Theatre Staff Present will be 85% complete	Nursing	End of Q1
	Role Description will be 85% complete	Nursing	End of Q1
Concordance (iPM and Theatre Log Book)	**Procedure**		
	Surgical Procedure Name will be 85% in agreement	Consultant/Surgeon	End of Q4*
	Laterality of Surgical Procedures will be 80% In agreement	Consultant/Surgeon	End of Q1
	Out of theatre will be 80% in agreement	Nursing	End of Q1
	Team		
	Theatre Staff Present will be 85% in agreement	Nursing	End of Q1
	Role Description will be 85% in agreement	Nursing	End of Q1
Timing	Surgical Procedure Code Time will be confirmed in 80% of instances	Consultant/Surgeon	End of Q1
Updates			
Staff Changes	IT to be informed of change in staffing before new medical/nursing staff arrive in theatre	Link Anaestetist and Nurse	End of Q1
New Procedures	IT will be informed if additional procedure codes are required	Consultant	End of Q1
Glossary: *Quarter 1(Q1) End March 2014, Quarter 4 (Q4) End of December 2014			

The KPI targets were based on what could realistically be achieved within the short pretest-posttest timeframe. Nevertheless, they are set to challenge the theatre to improve data quality. The document "*Guidance on Developing Key Performance Indicators*", suggests the importance of setting targets that balance achievability and challenge (HIQA 2013b). For instance, the 80% targets set for the concordance of laterality scores (13% pretest), surgical procedure code confirmation and laterality specification is well above the original completeness scores (46% & 26%, respectively). However, these targets were identified as the agreed minimum standard required. A less ambitious target of 85% by the end of quarter four was set for the concordance of the surgical procedure name (82% pretest). This target was realistic, given that procedure coding is complex and will require more time and resources to resolve. The KPIs set for clinician and IT linkage was not measured, as this was outside the scope of this research. While these targets are seen to be achievable, they are subject to change in the future, based upon the findings from phase 2 and clinician's views.

4.4 Conclusion

This chapter detailed the quality measures put in place following phase 1 of the data collection. The findings were presented within a SWOT analysis framework. The data quality strengths were the completeness and concordance rates of administrative data and completeness in the timings of procedural data. Data weakness were found in the completeness and concordance rates of procedural data (laterality and surgical procedure code confirmation), in-theatre staff census (staff present and role description) and timeliness in confirming procedure codes. A total of nine opportunities and nine threats were identified arising from this investigation. KPIs were set based on the findings from phase 1 of the study. The next chapter will present the pretest-post-test analysis.

Chapter Five Findings and Analysis

5.1 Introduction to Findings and Analysis

Chapter 4 detailed the quality measures put in place following phase 1 of the data collection. This chapter presents the pretest-posttest findings and analysis. Data tables can be viewed in appendix 2 (2.1-2.9). The chapter will present the following items;

- The characteristics of the surgical data sets.
- The frequencies for completeness, concordance and timeliness
- The analysis of individual data fields for completeness, concordance and timeliness.
- The differential between completeness and concordance scores pretest-posttest.
- The gaps in data quality
- The Null hypothesis test

5.2 Characteristics of the Data Set

For analysis purposes the surgical record was subdivided into three data sets; completeness (18 data fields), concordance (15 data fields) and timeliness (1 data field) (Table 5, Chapter 3). The forename and surname were merged together and identified as the "patient name". Presentation of data analysis therefore consists of 17 data fields for completeness and 14 for concordance.

The data quality of 148 surgical records was measured; 70 in the pretest phase and 78 in the posttest phase. A number of surgical procedures had more than one occurrence, resulting in 48 coded procedures pretest and 43 posttest. The assessment of data quality resulted in the analysis of 5,032 data entries, which were crossed referenced against 148 theatre log entries. Record retrieval for the theatre log and iPM matched 100 per cent. The length of surgery (surgery start to completion time) ranged from 18 minutes to 2 hours 25 minutes pretest to 20 minutes to 3 hours 30 minutes posttest.

5.3 Key Performance Indicators

The KPIs arising from phase 1 were used as standards or targets to be attained in phase 2 Table 12 shows that of the 14 KPI measured, half were achieved (50% n=7). For completeness, 5 out of the 8 KPIs were achieved (63%, n=8). For concordance, 2 out of the 5 were achieved (40%, n=5). The KPI targets set for iPM staff and procedure updates

was met, as IT staff receive more regular communication, however these were not objectively measured. The surgical procedure code confirmation and laterality of surgical procedures fields were identified as the least met targets.

For concordance, the laterality score was considerably lower than the set target. The score for timeliness and confirming surgical procedures was also well below target. The clinical significance of these findings will be discussed in greater detail in chapter 6.

Table 12: KPIs Posttest

Surgical Data Quality Key Performance Indicators Posttest					
DATA QUALITY DIMENSIONS	TARGETS FOR DATA QUALITY	PERSON RESPONSIBLE	DATE 2014	Score Achieved %	STATUS Achieved √
Completeness iPM	Procedure				
	Surgical Procedure Name will be 95% correct	Consultant/Surgeon	End of Q1*	93	x
	Surgical Procedure Code Confirmation will be complete in 80% of instances	Consultant/Surgeon	End of Q4*	44	x
	Laterality of Surgical Procedures will be 80% completed	Consultant/Surgeon	End of Q1	51	x
	Surgery Start Time will be 95% complete	Nursing	End of Q1	100	√
	Surgery Complete Time will be 95% complete	Nursing	End of Q1	100	√
	Out of theatre will be 95% complete	Nursing	End of Q1	100	√
	Team				
	Theatre Staff Present will be 85% complete	Nursing	End of Q1	89	√
	Role Description will be 85% complete	Nursing	End of Q1	89	√
Concordance iPM and Theatre Log Book	Procedure				
	Surgical Procedure Name will be 85% in agreement	Consultant/Surgeon	End of Q4	84	x
	Laterality of Surgical Procedures will be 80% in agreement	Consultant/Surgeon	End of Q1	44	x
	Out of theatre will be 80% in agreement	Nursing	End of Q1	82	√
	Team				
	Theatre Staff present will be 85% in agreement	Nursing	End of Q1	81	x
	Role Description will be 85% in agreement	Nursing	End of Q1	86	√
Timing	Surgical Procedure Code Confirmation will be carried out within set time rules in 80% of instances	Consultant/Surgeon	End of Q1	24	x
Updates					
Staff Changes	IT will be informed of change in medical/nursing staff prior to their arrival in theatre	Link Clinician(s)	End of Q1		√
New Procedures	IT will be informed of the need to add procedure codes	Consultant	End of Q4		√
Glossary: *Quarter 1 (Q1) End March; Quarter 4 End December 2014					

5.4 Pretest-Posttest Data Quality

The aim of the study was to determine if quality measure, based on the secondary data, led to improvements in data quality. Table I3 (Appendix 2.1, 2.2, 2.4, 2.5) shows the improvement in the completeness of iPM records and in the concordance levels between iPM and the theatre log book. There was no improvement in the timeliness of confirming the surgical procedure code (Appendix 2.3, 2.6). The mean score for completeness (88% versus 92%) and concordance (84% versus 89% posttest) improved, with an inverse score

for timeliness (27% versus 24%). The clinical significance of these results will be discussed in chapter 6.

Table 13: Data Quality Frequencies

5.5 Completeness Scores

The completeness of the surgical record (breadth) improved pretest-posttest as mentioned previously (Table 13). Further analysis was undertaken for surgical records that were 90-100% complete. The analysis showed significant improvement in the levels of completeness (41% versus 58%, p=00045) (Table 14 & Appendix 2.8). This is clearly seen in the surgical record data range pretest (minimum 0.50–maximum 0.99) versus posttest (minimum 0.81–maximum 1.00). This demonstrates a very positive trend, moving towards full completeness of surgical records.

Table 14: Total Surgical Record Completeness

Surgical Record Completeness, 90-100%			
Data Dimensions	**Mean Score Pretest**	**Mean Score Posttest**	pValue (1 tailed Confidence level)
Concordance	0.41	0.58	0.0045

Completeness scores (Table 15 & Appendix 2.1, 2.4) for individual data fields showed high levels of improvement in a number of areas. Administrative data achieved 100% completeness posttest. Procedural data demonstrated a number of improvements between pretest and posttest findings. Theatre timing fields (into theatre, surgery start and surgery complete) all attained statistically significant improvement (94% versus 100%, p = 0.017429). The surgery complete field also showed a statistically significant increase (93% versus 100%, p=0.010724).

In the Team domain, data completeness improved across the three fields. Data quality significantly improved for staff present at surgery and role description fields (79% versus 89%, p=0.02275).

Table 15: Completeness Analysis

Completeness Analysis per Surgical Data Field			
	Pretest	Posttest	
Category	iPM Score	iPM Score	pValue (1 tailed Confidence level)
Administrative			
Patient Name	1.00	1.00	0.000000
MRN	1.00	1.00	0.000000
Date of Birth	1.00	1.00	0.000000
Operative Description	0.99	1.00	0.393580
Theatre Name	1.00	1.00	0.000000
Speciality	1.00	1.00	0.000000
Procedure			
Date of Surgery	1.00	1.00	0.000000
Into Theatre field	0.94	1.00	0.017429
Surgery Start field	0.94	1.00	0.017429
Surgery Complete field	0.93	1.00	0.010724
Out of Theatre field	0.94	1.00	0.017429
Surgical Procedure Name	0.92	0.93	0.409046
Laterality of Surgical Procedure	0.26	0.51	< 0.00001
Surgical Procedure Code Confirmation	0.46	0.44	0.374484
Team			
Consultant Name	0.97	0.99	0.166023
Theatre Staff Present	0.79	0.89	0.02275
Role Description	0.79	0.89	0.02275

Two area of weakness were noted. Laterality confirmation showed a significant increase in completeness, (26% versus 51%, p=<0.00001), however, the overall score remained well below the KPI target set at 80%. Secondly, the surgical procedure code confirmation field showed a non-significant reduction in scoring between the pre and posttest analysis (46% versus 44%, p=0.374484). These fields were identified as falling well below the KPI target of 80% (Table 12, Section 5.3).

5.6 Concordance Scores

The concordance between surgical record sources improved pretest-posttest as mentioned previously (Table 13). Further analysis was undertaken for surgical records that were 90-100% in concordance. As seen from table 16 (Appendix 2.9), very significant levels of improved concordance was achieved (33% versus 58%, p=0.0000). This level of improvement is very clearly seen in the concordance range pretest (minimum 0.07 to maximum 0.97) versus posttest (minimum 0.68 to maximum 1.0). These findings indicate high levels of reliability and accuracy in iPM data.

Table 16: Total Surgical Record Concordance

Total Surgical Record Concordance 90-100%			
Data Dimensions	**Mean Score Pre-Test**	**Mean Score Post-Test**	pValue (1 tailed Confidence level)
Concordance	0.3286	0.5769	0.0000

Concordance scores (Table 17 & Appendix 2.2, 2.4) for individual data fields showed high levels of consistency in many of the data fields. The data quality improved in each of the Administrative data fields, with significant improvement in the operative description field (81% versus 95%, p=001589).

Procedural data demonstrated a number of improvements, two fields reaching statistical significance. The out of theatre time field (69% versus 82% p=0.011604) and laterality specification (13% versus 44%, p=<0.00001). The laterality is identified as a weakness in data quality, and remains well below the KPI targets set (80%, Table 12). The finding for laterality will be further analysis in section 5.10.

For the Team data, concordance improved across the three data fields, but did not reach statistical significance. The consultant name showed greater levels of consistency (90% versus 97%, p=0.026803), similar to theatre staff present (72% versus 81%, p= 0.052616) and the role description (77% versus 86%, p=0.04093) field. The role description field met the KPI target set at 85%, but the theatre staff present field was just short of this (Table 12). This suggests that greater linkage with IT is required, for more regular updates of staff.

Table 17: Concordance Analysis

Concordance Analysis per Surgical Data Field			
	Pretest	Posttest	
Category	iPM Score	iPM Score	pValue (1 tailed Confidence level)
Administrative			
Patient Name	0.99	1.00	0.4009
MRN	0.97	1.00	0.070781
Date of Birth	0.99	1.00	0.200454
Operative Description	0.81	0.95	0.001589
Theatre Name	0.93	0.95	0.261086
Speciality	0.99	1.00	0.200454
Procedure			
Date of Surgery	1.00	1.00	0.0000
Into Theatre field	0.90	0.92	0.294599
Out of Theatre field	0.69	0.82	0.011604
Surgical Procedure Name	0.82	0.84	0.337243
Laterality of Surgical Procedure	0.13	0.44	< 0.00001
Team			
Consultant Name	0.90	0.97	0.026803
Theatre Staff Present	0.72	0.81	0.052616
Role Description	0.77	0.86	0.04093

5.7 Timeliness Scores

The timeliness of surgical procedure code confirmation was an area of weakness, with a non-significant drop in score pretest-posttest (27% versus 24% posttest, p=0.3155) (Table 18 & Appendix 2.3 & 2.6). This score is well below the KPI target of 80% set for timeliness (Table 12).

Table 18: Timeliness Analysis

Timeliness Analysis Pre and Post Test			
	Pretest	Posttest	
Category	iPM Score	iPM Score	pValue (1 tailed Confidence level)
Procedure			
Surgical Procedure Code Confirmation Time	0.27	0.24	0.3155

Further data mining showed that a number of surgical procedures were confirmed in advance of the end of surgery time (Appendix 2.3 & 2.6). This finding applies to 10% of the total number of procedures pretest (n=7) and 10% posttest (n=8). Of this 10%, 57% (4, n=7) were outside the 10% timing rule pretest and 63% posttest (5, n=8). The data quality in relation to timeliness will be further analysed in chapter 6.5

5.8 Completeness Concordance Pretest

There were high level of disparity between completeness and concordance results in a number of field as shown in table 19. The greatest disparity was found in the out of theatre field, with a 25% difference between completeness and concordance (94% versus 69%) scores. The operative description field, showed an 18% gap between completeness and concordance (99% versus 81%) and laterality specification was 13% (26% versus 13%). The disparity in the surgical procedure name was 10% (92% versus 82%). A moderate level of 7% disparity was seen in the following fields; theatre name (100% versus 93%), consultant name (97% versus 90%) and theatre staff present (79% versus 72%). These findings highlight the importance of measuring more than one data quality dimension, as combined dimensions add to the robustness of the study and may highlight different clinical errors (Hogan and Wagner 1997).

Table 19: Completeness and Concordance Scores Pretest

Completeness and Concordance Scores Pretest			
	Completeness	Concordance	Score Difference
Category	iPM Mean Scores		
Administrative	%	%	%
Patient Name	100.00	99.00	1.00
MRN	100.00	97.00	3.00
Date of Birth	100.00	99.00	1.00
Operative Description	99.00	81.00	18.00
Theatre Name	100.00	93.00	7.00
Speciality	100.00	99.00	1.00
Procedure			
Date of Surgery	100.00	100.00	0.00
Into Theatre field	94.00	90.00	4.00
Out of Theatre field	94.00	69.00	25.00
Surgical Procedure Name	92.00	82.00	10.00
Laterality of Surgical Procedure	26.00	13.00	13.00
Team			
Consultant Name	97.00	90.00	7.00
Theatre Staff Present	79.00	72.00	7.00
Role Description	79.00	77.00	2.00

5.9 Completeness Concordance Posttest

The disparity in completeness and concordance was greatly reduced posttest as seen in table 20, with higher level of agreement in 9 of the 14 fields (Table 19 & table 20). Once again this demonstrates improved levels of reliability in the electronic record. The top six improvements in pretest-posttest score differences are listed as follows;

- Operative description (18% down to 5%).
- The out of theatre time (25% down to 18%).
- Laterality specification (13% down to 7%).
- Consultant name (7% down to 2%).
- MRN disparity (3% versus full agreement).
- Theatre name (7% down to 5%).

Table 20: Completeness and Concordance Scores Posttest

Completeness and Concordance Scores Posttest			
	Completeness	**Concordance**	Score Difference
Field Categories	iPM Mean Score		
Administrative	%	%	%
Patient Name	100.00	100.00	0.00
MRN	100.00	100.00	0.00
Date of Birth	100.00	100.00	0.00
Operative Description	100.00	95.00	5.00
Theatre Name	100.00	95.00	5.00
Speciality	100.00	100.00	0.00
Procedure			
Date of Surgery	100.00	100.00	0.00
Into Theatre field	100.00	92.00	8.00
Out of Theatre field	100.00	82.00	18.00
Surgical Procedure Name	93.00	84.00	9.00
Laterality of Surgical Procedure	51.00	44.00	7.00
Team			
Consultant Name	99.00	97.00	2.00
Theatre Staff Present	89.00	81.00	8.00
Role Description	89.00	86.00	3.00

The level of concordance and completeness disparity ranges did not reduce posttest in three fields as shown;

- Into theatre time (4% versus 8%).
- Theatre staff present (7% versus 8%).
- Role description (2% versus 3%).

This demonstrates that concordance rates did not keep pace with the increase in completeness rate of electronic recording

5.10 Laterality Scores

The analysis pretest-posttest show a statistically significant improvement, both in completeness (p=<0.00001) and concordance (p=<0.00001) for laterality specification.

Further data mining showed while data quality appeared to have improved, the result was flawed. In fact, laterality was specified for 3% of cases pretest and posttest (Figure 11 and 12). The relative improvement was proportionate to the number of pre-coded procedures in iPM and the number of procedures where laterality applied (Figure 11 and 12, Appendix 2.7).

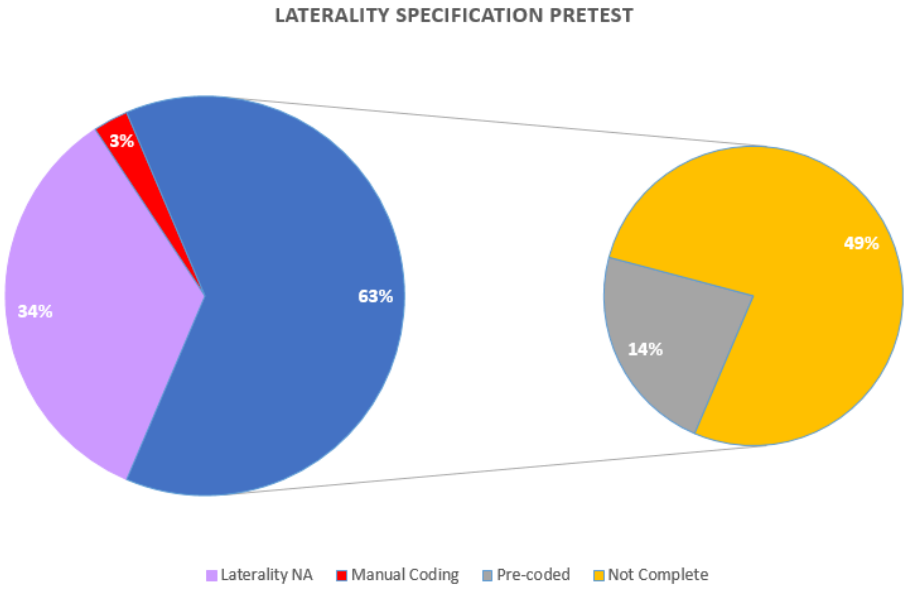

Figure 11: Laterality Coding Pretest

As seen in figure 11, 14% of procedures were coded pretest versus 28% posttest (figure 12). Laterality did not apply to 34% pretest surgical procedures versus 45% post-test.

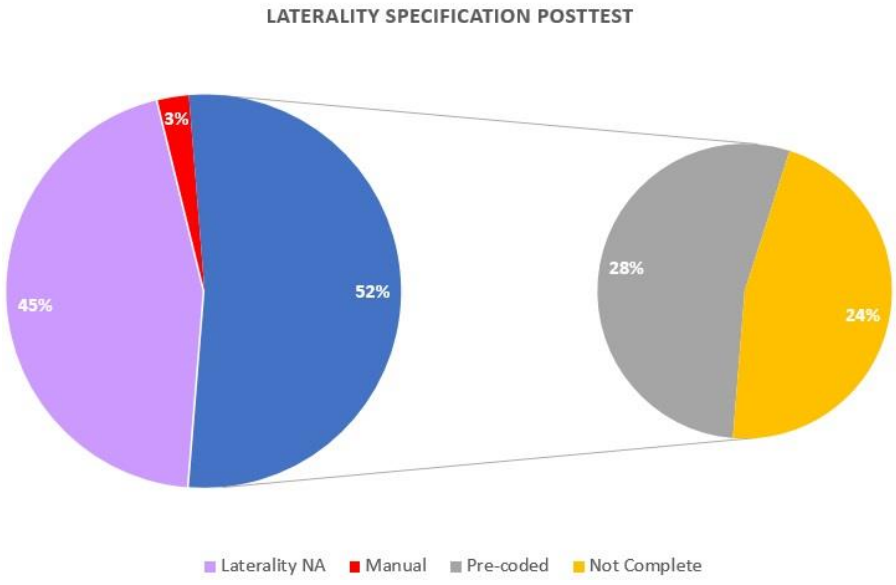

Figure 12: Laterality Coding Posttest

Therefore, future measurement of this data field needs to take into account the number of procedures pre-coded and the number of procedures where laterality applies. The clinical importance of laterality specification will be discussed in chapter 6.7.

5.11 Hypothesis

The hypothesis tested was secondary use of the secondary will lead to improvement in electronic data quality

The null hypothesis was set as H_o: $p_1 = p_2$ and was sub-sectioned as follows;

1. The pretest and posttest mean will be equal for completeness.
2. The pretest and posttest mean will be equal for concordance.
3. The pretest and posttest mean will be equal for timeliness.

An alternative hypothesis was set as is Ha : $p_1 < p_2$ and was subsection as follows;

1. Posttest mean will be greater than pretest for completeness
2. Posttest mean will be greater for concordance
3. Posttest mean will be greater for the timing of surgical procedure confirmation

Table 21 shows that there improvement in two of the three measures pretest-posttest, but this was not statistically significant.

Table 21: Data Quality Analysis

Data Quality Analysis per Data Dimension			
	Pretest	Posttest	
Data Dimensions	**iPM Mean Score**	**iPM Mean Score**	pValue (1 tailed Confidence level)
Completeness	0.88	0.92	0.1288
Concordance	0.84	0.89	0.1105
Timeliness	0.27	0.24	0.3155

There was a non-statistical significant improvement shown for completeness (88% versus 92%, p = 0.1288). Similarly for concordance, there was a non-statistical significant improvement (84% versus 90%, p=0.1105). Timeliness did not show improvement, with a non-statistical significant inverse score (27% versus 24% posttest, p=0.3155). The P value was set at <0.05, therefore, the Null hypothesis is accepted. The study did not demonstrate secondary use of data led to improvement in data quality in the theatre setting.

5.12 Conclusion

This chapter presented the pretest-posttest findings and carried out an analysis of these findings. The results from the KPIs showed that half were met, with a greater number of targets achieved in the data completeness section. Overall, a high level of data quality was achieved, 92% for completeness and 89% for concordance, with a greater margin of improvement seen in relation to concordance. Surgical records between 90-100% for completeness and for concordance showed significant levels of improvement. Individual fields for completeness demonstrated very positive trends, with a total of seven fields showing statistically significance levels of improvement. The individual data fields for concordance showed statistically significant improvement in three of the fourteen fields. analysed. The timeliness of confirming surgical procedures did not show improvement during the study period and attained a posttest score of 24%. A comparison of completeness concordance pretest-posttest demonstrated that the disparity between these quality measures reduced in nine of the fourteen fields. Laterality scores were not found to be statistically significant following a more in-depth analysis. The null hypothesis was accepted.

In the next chapter, the findings will be discussed and evaluated.

Chapter 6: Discussion and Evaluation

6.1 Introduction to Discussion and Evaluation

Chapter 5 presented the study findings and analysis. This chapter looks at the significance of the main findings of the study and undertakes a comparison with previous studies, where possible. An in-depth analysis of the most significant findings in relation to completeness, concordance and timeliness of electronic data will be provided. The findings from two areas of interest, surgical procedure coding and laterality specification will also be discussed. Methods to bring about quality improvement such as education, training and motivational issues will be discussed along with an in-depth analysis of the quality measures used in the study. An overview of the future state for measuring data quality will be provided.

6.2 Meeting the study aims and objectives

The aim of the study was to determine if quality measure, based on secondary use of data, lead to improvement in data quality. Non-statistical improvements was achieved in the completeness and concordance of electronic surgical records. The results showed a statistically significant improvement for completeness and concordance (between 90-100%) in surgical records. Timeliness in confirming the surgical procedure code did not show an improvement. Statistical significance was attained in many individual components of the surgical data sets.

The objective of developing a methodology for the assessment of data quality was met as an eight step quality process was developed including a scoring system to measure data quality. Statistical analysis were used to measure the data. The gaps in the data were identified as confirming the procedure code, specifying laterality and the timeliness in confirming the surgical procedure code. Quality intervention tools such as SWOT and KPI play an important role in improving data quality, particularly when combined with secondary use of clinical data. KPIs were successfully deployed to monitor performance posttest and identify if important clinical targets were attained. The data integrity report helped clinicians improve the completeness of records. The findings show that secondary use of data can and should be used by clinicians to improve data quality.

6.3 Completeness

Completeness was defined as ""*Data that has all the items required to measure the intended activity or event*" (HIQA 2012b). The dimension 'completeness' was assessed in two ways. Firstly, for the individual components of the data set and secondly across the entire breadth of the surgical record (18 item surgical data set). Measuring the completeness of the different granularities (detail) served different purposes. Individual data components are used to monitoring theatre activity over time (i.e., surgical start and finish times, type of procedures performed), whereas the entire patient's surgical record is used for audit and occasionally for medicolegal purposes. Previous studies have also shown that the magnitude of completeness make it possible to cater for different data usage (Weiskopf et al 2013b; Wang and Strong 1996; Pipino et al 2002).

Data completeness in this study compares favourably with other studies. Wrightson's (2010) study showed electronic field completeness in anaesthetic records was 78% as opposed to 92% in this study. Roukema et al (2006) evaluated the completeness of electronic versus paper documentation in a paediatric setting. The results showed that the electronic records contained approximately 65% of the information present in the paper record. Weiskopf et al (2013b) tested four prototypical definitions of completeness using data from New York-Presbyterian Hospital clinical data warehouse. The study showed poor levels of data quality across the four areas examined, with a total of 26.9% records meeting the set criteria for completeness. Data completeness is one of the most frequently studies dimensions (Weiskopf and Weng 2013a; Chan et al 2010). However, due to contextual nature of completeness, differences in information system and different clinical focus, it is difficult to draw conclusions on the quality of data completeness. This same sentiment was expressed by Weiskopf and Weng (2013a).

Data entry improved in the study with high levels completeness attained posttest. This may be attributed to the study feedback, the hawthorn effect (also known as the observer effect) or to the implementation of data integrity reports. Regular monitoring of data is time consuming, therefore, the automated process was likely to have an impact, though this was not specifically measured. Other software solutions such as "pop-up" alerts and mandatory field entry have been shown to be effective in improving data quality (Berner, 2009; Miller et al 2005) and may provide additional solutions to improving data

completeness. However, it is unlikely they would have an impact on laterality confirmation, due to the contextual nature of this component.

From a healthcare perspective, complete data fields are important for patient management, performance monitoring and research (Wrightson 2010; HIQA 2013a). The completeness of data also carries medicolegal implications and has an expanding role in costing and billing calculations (Vigoda and Lubarsky 2006). Incomplete data have no worth in decision making and restricts the ability to conduct data analysis, monitor theatre performance and theatre utilisation (Audit Commission 2003; RCSI 2013; NHS Scotland 2006). Due to the high level of completeness in individual fields and in the surgical record post-test, it is recommended that theatre staff should consider moving towards the electronic record. The next section looks at a second quality dimension, concordance, with a degree of overlap seen. This overlap is a recognised phenomenon within data quality research (Wang and Strong 1996).

6.4 Concordance

Concordance was defined as "*Agreement between elements in the EHR, or between the EHR and another data source*" (Weiskopf and Weng 2013a). In this study, concordance was assessed by the level of surgical field agreement between the theatre log book and the electronic record. This has relevance, as clinicians need to be satisfied that the electronic data is at least as accurate and reliable as paper based records before transiting to the electronic record (Mikkelsen and Aasly 2001; Stausberg et al 2003). Also comparing the information from two data holdings added to the rigour of the study.

Of particular note was the level of availability of surgical records. Surgical procedures recorded in iPM and the theatre log book matched 100% and were retrievable, indicating the high maintenance of record keeping within the theatre complex. However, it was outside the scope of this study to identify the availability of surgical procedure notes within the patients' medical record. Record retrieval was identified as a weakness in other studies. Record retrieval was 90% for electronic records and 83% in handwritten anaesthetic records in Wrightson's (2010) study. Mikkelsen and Assly (2001) found record retrieval was 87% for electronic records and 99% for handwritten neurology department records (Wrightson, 2010; Mikkelsen and Assly 2001). The ease of retrieving and accessing records is a very compelling argument for adoption of election records in many studies

(Uslu and Stausberg 2008) and is identified as an important measure of data quality (HIQA, 2013b; Mikkelsen 2005).

This study showed improved concordance between handwritten and electronic surgical records (84% pretest and 90% post-test), suggesting that structured feedback to clinicians can lead to improvement in quality. The finding in this study compares favourably with other studies, notwithstanding the difference in methodologies. Many studies compared the measurement of two data sources, the electronic records and handwritten records (Stausberg et al 2003; Overhage et al 2008; Wrightson, 2010; Neri et al 2014), without selecting a gold standard. Wrightson (2010) compared 60 handwritten with electronic anaesthetic records and showed no significant difference between the two sources (78 v 83%, p=0.16). A randomised controlled trial comparing 200 anaesthetic and 200 electronic based anaesthetic records, showed that electronic records were more complete than handwritten records (mean difference 7.1%, p=<0.0001) in 32 predefined items (Edwards et al 2013).

Wrightson (2010) noted that handwritten records were difficult to read and at times illegible. Similarly in this study, reading handwritten entries was difficult, particularly the procedure name(s) and the staff present components. Illegible records added to the time taken to validate the study data and may have led to some recording inaccuracies as highlighted in previous studies (Farzandipour and Sheikhtaheri 2009; Häyrinen et al 2008; Wrightson 2010). The ability to record important information in a standardised and legible record has significant clinical advantage. Improved documentation and reducing medical errors that arise from illegible records is a fundamental reason for implementing an EHR (Kemper 2006; Wrightson 2010; RCSI, 2013).

The maintenance of both electronic and paper based systems is challenging, especially as updating one system does not result in update of the other. Without simultaneous updates, information inconsistency may arise (Stausberg et al 2003). This leads to frustration and impairs clinicians efficiency, as several items may need to be checked to identify the truth (Mikkelsen and Aasly 2001). It is perceived that complete transition to an electronic record could reduce paper based problems, ease the production of data and associated reporting abilities, advantaging the theatre setting (Yoon-Flannery 2008; Uslu and Stausberg 2008; Couralet et al 2013)

The concordance of data sources is of great importance and as identified in the literature review, information needs to be accurate and reliable to be of value. Mikkelsen and Aasly (2001) suggest the consequences of misinformation is potentially more serious than missing/incorrect information. Similarly, Faulconer and de Luignan (2004, pg 251) states "*the sins of commission are as big a problem as the sins of omission*", with reference to procedure coding. For parallel electronic and paper recording, it is recommended that on-going checks for concordance are carried out. The alternative is to switch to electronic recording and revise the data quality measures.

The next section discusses the third quality dimension assessed which was timeliness.

6.5 Timeliness

Timeliness was defined as "*Data collected within a reasonably agreed timeframe after the clinical event"* (HIQA, 2012b). The timeliness for surgical procedure confirmation was set as the time interval between surgery completion and out of theatre.

Approximately half the total number of surgical procedures where confirmed in a timely fashion (25% pretest versus 22% posttest, p=0.28774), which is concerning. This may have resulted for a number of reasons. The timing of documentation may not be seen as an immediate priority, entering the timing is not a mandatory field and the iPM system does not restrict the timing of any entry. As highlighted in other studies, data entries are recorded without regard for timing consideration (Vigoda and Lubarsky 2006). Documentation should ideally occur in real time, immediately after completion of a service (Maclean et al 2012; Vigoda and Lubarsky 2006). In reality, clinical practice is an interruption driven environment, where the workflow of HCPs is dynamically changing (Craswell et al 2012) resulting in data entry being deferred occasionally.

Timeliness is the least studied quality dimension (Weiskopf and Wang 2013a), perhaps due to other dimensions taking priority (CIHI 2009). However, as seen in a number of studies, data delay has real consequences. Vigoda and Lubarsky (2006) showed that prospective charting of anaesthetist emergence time from surgery was a cause for concern and in breach of safety guidelines. Vawdrey et al (2007) showed that data delay in an intensive care setting can adversely affect treatment decisions and situational awareness. Delays in clinical coding adversely impact on clinical reporting, research and reimbursement (Faulconer and de Lusignan 2004; Novitsky et al 2005).

For theatre staff, timely surgical procedure confirmation is important. Unless the surgical procedure is confirmed in a timely fashion, it may be recorded less accurately, or not recorded (Hogan and Wagner 1997; Craswell et al 2013; Vigoda and Lubarsky 2006). Fundamentally, the surgical procedure recorded is part of the patient's medical record and has a legal basis. According to Vigoda and Lubarsky's (2006) study, one of the unanticipated consequences of transitioning from paper to an electronic record is the effect on data entry practices. Electronic records may be used by regulatory and medicolegal agencies to review specific date/time notations of each entry. Audit trails, are still in the early stage of development and are not widely used or known currently outside of IT (Cruz-Correia 2013; Chan et al 2010). However, it is likely in the near future that usage will become more widespread, thereby enhancing traceability.

Timeliness is often connected with delay, however timeliness can also be impacted by prematurity. In this study, a number of surgical procedures where confirmed in advance of the surgery completion time. Of the surgical procedures confirmed, 10% of cases (pretest-posttest) were confirmed in advance of the surgery completion time. This practice may lead errors in the documentation. A study by Vigoda and Lubarsky (2006) found that anaesthesiologist emergence time occurred earlier than 30 minute from the end of surgery time. This was considered to be unsafe practice. Vigoda and Lubarsky's (2006) study did not take into account different lengths of surgery. This was addressed in the present study, to account for surgery time variability (range 18 minutes to 3 hours 30 minutes). The researcher suggests that the 10% rule applied in this study is a valuable metric when measuring the timeliness of surgical procedure confirmation.

As asserted, the importance of measuring timeliness cannot be underestimated. The anticipated benefits of timely data entry may increase the accuracy of surgical procedure data. This would have positive effects in terms of the patient record, from a medicolegal perspective and would lead to a more accurate reflection of theatre activity (i.e., cases completed) for reporting purposes. The next section discusses clinical coding, as this was an area of weakness in the study.

6.6 Procedure Coding

Confirming the surgical procedure code is an essential activity, as this is part of the patient's surgical records and there is a reliance on this information for reporting purposes. The

findings in this study show that surgical procedure confirmation score was poorly completed, with a non-significant decrease in scores between pre and post assessment (range 46% to 44%, p=3.74484). However, the concordance scores ranged from 81% pretest rising to 95% posttest, indicating that there was a good level of agreement for procedure names, despite poor confirmation rates. It must be borne in mind that confirming the procedure code was a relatively new task as indicated at the beginning of the study Additionally, the mapping of local codes to ICD codes is ongoing as part of the iPM implementation.

Though not directly comparable with this study, there are a plethora of studies indicating poor compliance, and problems with the levels completeness and accuracy of clinical coding (Roukema et al 2006; de Lusignan et al 2005; Maclean et al 2012; Arthur and Nair 2004; Chan et al 2010). The National Theatre Project in NHS Scotland showed that theatre data is a poor reflector of theatre activity, at a standard of 90% accuracy (NHS Scotland, 2006). Similar to other studies, the findings in this study showed poor levels of surgeon's engagement with clinical coding. The NHS Information Centre survey of 1081 NHS hospital consultants and found low engagement (21%) with clinical coding (Spencer et al 2012). This may have implications for data quality.

Surgical procedures are recorded electronically as structured, rigid procedure codes within iPM. This can frustrate surgeons and nurses as the complexity, granularity and variability that is possible with free text is lost (Rector, 1999; Hardiker et al, 2002, Benson, 2009). As stated by Rector (1999), the recording of clinical care and surgical procedures need fine grained detail to direct and manage surgical care, whereas less detail is required for reporting purposes i.e., a right posterior frontal craniotomy may be recorded as "craniotomy" for reporting purposes. Physicians find structured electronic documentation the least satisfying method of recording (Neri et al 2009). Strategies put forward to improve clinical coding include the following;

- Wider clinician involvement (Spencer, 2011)
- Training for clinicians (Craswell et al 2012; Mikkelsen and Aasly, 2005).
- Algorithms which identify likely misdiagnosis (de Lusignan et al, 2010).
- Computer-assisted coding (CAC) systems to help clinicians search and find codes (Terry, 201; Nuance Healthcare, 2014).

- Messaging standards such as SNOMED CT to enhance the capture of clinical terminology at the point of care and to support ICD 10 coding (HIQA, 2013c).

Despite the challenges faced with clinical coding, there are clear advantages to structured electronic data. The most notable being more complete documentation (Cheung et al 2001; Häyrinen et al 2008), ease of retrieval (Mikkelsen and Aasly 2005) and the ease of large scale monitoring of clinical activity, which is not feasible for paper-based records (Chaudhry et al 2006). While confirming coding may not be seen as a priority at present, this may change in the future as clinical coding will underpin pay for performance, possibly incentivising clinical coding confirmation (DoH 2013b). Laterality specification, which is a feature of surgical procedure confirmation, is discussed in the next section.

6.7 Laterality

The completeness and concordance of surgical procedure laterality score increased significantly pretest to posttest. However the overall rate of laterality specification was poor. This result can be explained by a number of factors. There are reported difficulties in manually updating the laterality of procedures in the system, the interface is not considered user friendly and there was a glitch found in the system. An alert notice was sent to product users specifying that iPM version 3.0 posed a potential risk to patients who underwent multiple procedures. The system only displayed the last laterality added on theatre screen (Appendix 5.1, Product Alert Notice). These reasons may explain poor data quality in part, however there are other factors.

The quality of laterality coding was found to be relative to the number of pre-coded procedures in iPM and the number of procedures where laterality applies. This suggests that procedure coding should make provision for laterality. Clinical coding systems such as ICD 9 do not include laterality, whereas version 10 includes left, right, and bilateral specification for selected procedures (Simmons, 2011; Steindel, 2010). Appendix 6.1 identifies the primary sites requiring laterality information, which mainly relate to neoplasms, injuries and circulatory system disease.

Specifying laterality is an important aspect of safe surgery as indicated in the "*WHO Guidelines for Safe Surgery"* (WHO, 2009). An essential tool within these guidelines is a preoperative checklist to support safe preparation for surgery. Specifying laterality is frequently referred to within the guidelines. Wrong site surgeries do occur in healthcare,

albeit infrequently. Pronovost and Freischlag (2010) estimated that wrong site surgery is associated with 1% risk of overall surgical mortality. The WHO found that over 13% of reported adverse events were due to wrong-site surgery (WHO 2009). According to a report in the Irish Independent, 19 "wrong-site" surgeries took place in HSE hospitals between 2005 and 2010. These cases resulted in surgery to the wrong eye, kidney, ovary and leg (irishhealth.com, 2010). As this is an important patient safety issue, it is essential that the records correctly reflect the laterality of the surgery undertaken.

Despite the reported incidence of wrong site surgeries, there is a paucity of research in this area. Epidemiological research identifies the importance of laterality for investigating cutaneous melanoma (Brewster et al 2007). Studies have used laterality detail to investigate radiotherapy safety (Haque et al 2011), and reference has been made to the importance of laterality to investigate subsequent knee and hip surgery and surgical revision (Lyman et al. 2009). No comparative study was found in the area of data quality. This is clearly an area requiring further study.

From the gaps identified, it is evident that education and training are required to enable sustained improvement. The next section discusses the importance of training and development to improve data quality.

6.8 Education and Training

The findings in this study support the need for education and training, though this was not specifically measured within the study. The operating theatre have a high turnover of staff, particularly medical staff, who typically rotate every six months. This intensifies the need for on-going system training. Nurses are the largest group of users in theatre and are responsible for a significant part of the surgical data entry, thereby greatly influencing data quality. As indicated by Hahn et al (2013), the capacity of clinical information systems is greatly influenced by the individual skill and the behaviour of staff, therefore data management skills should be strengthened. This view was widely held by others (Osheroff et al 2004; Berner, 2009; HIMSS 2006). In turn, competence and training in system use is associated with improvements in data quality (Ayoub et al 2007; Craswell et al 2013; HIQA 2012b).

Fundamentals put forward for IT education include the following;

- Training should incorporate the benefits of data usage, the requirements for data quality, dimensions of data quality, and how data quality relates to a particular role (HIQA, 2012b).
- Build computer literacy within the organisation. The European Computer Driver Licence (ECDL) is becoming the recognised standard for nurses (Eley et al 2008).
- Education and training in ICT needs to take place at undergraduate level as is the case in Australia (Eley et al 2008; Craswell et al 2012).
- Widespread use of train-the-trainer roles. This is a widely acknowledged educational model to ensure ongoing competence (Orfaly et al 2005; Baker et al 2005).
- Link people (super-users) to support the initial and on-going interaction with healthcare systems (HIMSS 2006; Osheroff et al 2004).
- Training support and facilitation needs to be provided by employers and managers (HIQA 2012b; Audit Commission 2009).

Evidence from an Australian study of 10,000 nurses shows that IT training is not seen as a top priority, and workload issues (time and lack of relief staff) are seen as major barriers for training uptake (Eley et al 2008). This needs to be addressed if ICT is to support data quality and associated patient care. Closely linked to education and training is the motivation to use the electronic system.

6.9 Motivation

In this study, feedback from phase 1 of the study was one of the main motivators used to improve data quality. This method was successful in two of the three dimensions measured, but not for timeliness. In contrast, Vigoda and Lubarsky's (2006) found audit and feedback was successful in enhancing the timeliness of anaesthetic documentation. There was a fundamental difference in the timeframe of quality intervention between studies. Quality interventions took place over nine months in Vigoda and Lubarsky's (2006) study as opposed to two weeks in this study. This suggests that with greater time, regular feedback from data, quality audits, and training, greater impact may be achieved. This level of analysis was found to be effective in Cambridge University Hospitals where

regular 'deep dive' audits are undertaken to investigate the accuracy issues raised by monitoring (Audit Commission 2009).

It is noted that data input within doctor's area of responsibility was poor (i.e., surgical procedure confirmation, laterality specification, timeliness in confirming surgical procedure). This was in contrast with nurses data input, which improved considerably in the posttest period (in-theatre details, staffing roles and responsibilities). Social cognition theorists suggest that audit and feedback are effective interventions for behaviour change, but only in motivated populations who have agreed that the change in behaviour is desirable (Eccles et al, 2005; Foy et al, 2005). A number of techniques have been used to motivate HCP data entry and influence professional behaviour as highlighted in 2.12.1 to 2.12.3 of the literature review. Eccles et al (2005) suggests that professional behaviour can be modified and perhaps changed through behavioural theory techniques. This is an area deserving of further study. In the following section, the study methods and quality interventions will be analysed.

6.10 Quality Measures

6.10.1 Data Collection

One of the strengths of this study is the rigour in the approach to assessing data quality. A comprehensive approach was used to identify the type of data needed. It is feasible that these data sets could be used in the future to measure surgical data. This system of data collection supports the approach used in previous data quality investigations (Weiskopf, and Weng 2013a; Wang and Strong 1996).

6.10.2 Data Dimensions

The selected data quality dimensions, completeness, concordance and timeliness, were appropriate to measure theatre data in an Irish setting. In so far as known, these selected dimensions have not been used previously to measure the quality of theatre data, therefore, further research is required to validate these measurements

This study used structured data from a single system, which is the most common type of system in an Irish setting. To ensure that surgical data is "fit for purpose", it is suggested the following addition dimensions could be measured going forward.

- The **accuracy** of items such as procedure coding and laterality
- The **relevance** of the surgical data set currently in place

- The accessibility (**usability**) of the surgical data

6.10.3 Data Measurement

The scoring system used in the study helped eliminate biased, and facilitated a detailed statistical analysis of data quality. Overall the structure of the scoring system was successful in meeting a primary objective of identifying gaps in data quality. It also helped to understand the state of data quality across an entire surgical record. Areas of good data quality were identified and conversely, problematic areas were highlighted. Credit for incomplete data fields was given, as this information has an important role in the overall analysis of data quality. This supports Wrightson's (2010) research. The assessment scores are generic, therefore, the tool could be used to measure quality in other theatres or other areas of healthcare with similar presentation.

This systematic approach to measuring data quality addressed deficits found across other studies (Weiskopf and Weng, 2013a; Chan et al 2010; Teasdale et al 2007). Multiple stakeholder are calling for a common set of measures to enhance data quality measurement to ensure information is accurate, reliable and timely (HIQA 2013b; Teasdale et al 2007; RCSI, 2013). One of the most prominent frameworks to measure data quality was developed by the CIHI (Long 2001). This framework facilitates the measurement of data quality across five areas; accuracy, timeliness, comparability, usability and relevance, and is held in high regard in the literature (Batini et al 2009; Long, 2001). HIQA believe that this framework could be adopted in the Irish setting, as a means of standardising the measurement of data quality (HIQA correspondence Appendix 8.1)

6.10.4 Research Methodology

Unlike prior studies investigating data quality, the researcher used a TDQM approach in tandem with research methodology. This served to combine data quality investigation with data improvement. The combination of Weiskopf et al (2013b) framework for measuring the completeness of data quality and Wang's (1998) TDQM framework was theoretically grounded and provided a pragmatic approach to data capture, measurement, analysis and improvement. This approach to data quality improvement supports the CICI framework (CIHI 2009). .

The use of SWOT analysis as a structure for feedback (pretest findings) was successful as it helped condense the results and provided a structure for the presentation of results. The

opportunities and threats elements were particularly helpful for identifying the influential environmental factors. The use of this tool supports former studies (Helms et al 2008; Lamontagne et al 2011;Toivanen et al 1999).

KPIs were key quality interventions used in this study. The KPIs served as a useful guide to identify performance improvement against the target set from phase 1. Fifty per cent of the KPI were unmet, which demonstrates the need to review the metrics in light of the post analysis findings. It is likely that the KPIs may have been set too high for timing and for surgical procedure confirmation, given that work was still in progress in these areas. Additionally, the KPIs were set with a nurse managers, and not set in conjunction with theatre staff involved in data input, due to time constraints. Consulting with key stakeholders is a fundamental part of developing KPIs to gain agreement, ownership, and would increase the likelihood of adoption (HIQA 2013b). It is recommended the theatre team review these KPIs, but fundamentally the KPIs should be used to drive improvements in data quality.

6.10.5 Secondary Use of Data

In this study, secondary use of data has been used as part of a TDQM process to improve data quality. This was successfully employed as improvement was seen across ten of the surgical fields for completeness and thirteen field for concordance. It is not new that secondary use of data is used drive improvements in healthcare. As previously identified in the literature review, section 2.5, the secondary use of data yields significant benefits in terms healthcare decisions making, service delivery and research development (HIQA 2012a; Teasdale et al 2007; Tolar and Balka 2012; Safran et al 2007). Notwithstanding this, in the researcher experience, the potential of secondary use of data in clinical setting not well known and it remains an underutilised resource in day-to-day practice. The term "secondary use of data" is not familiar in clinical circles, therefore, increased awareness is required. It is likely that business intelligence tools such as quality dashboard, statutory and regulatory bodies, and the study of health of informatics will help raise the profile of secondary use of data at clinical level.

In Ireland, large data warehouses are not available to researchers as yet. However, this is set to change with increasing amount of technology use, the e-health strategy for Ireland, the imminent arrival of the EHR will drive the "Big Data" industry here in Ireland (HIQA 2012a; DoH 2013a). Complex ethical and legal issues which surround secondary use of

health data have been identified in the literature review sections 2.6. The researcher would support the views of researchers who suggest that repurposing secondary use of data is difficult, time consuming, laborious and poses a technical challenge (AHRQ 2007; Morrison et al 2013). The manual data extraction of this data set was possible, however this method is not feasible or desirable for EHR applications or large datasets, such as those exiting in the UK and US. This view is held by a number of researchers (Morrison et al 2013; AHRQ 2007; Rabinovich and Cheon 2011; de Lusignan and van Weel 2006).

While the purpose of secondary use of data was to improve data quality, a deeper understanding of data protection issues was also gained. Researching surgical patient data was a concern at the outset, as it was deemed inappropriate to seek consent from vulnerable patients. Patient consent was not required in this study, as it was conducted within the boundaries of the data controller and was anonymised. This position was further clarified in an e-mail from the office of the data commissioner (Appendix 9.1). It is recommended that information leaflets be made available at the study hospital. This is in line with best practice recommendations (Data Protection Commissioner, 2007).

6.11 Measuring Data Quality – future state

The future state for measuring data quality has a dependency on technological advances, legislation and regulation to mention but a few. Some of the most significant are listed below, based on recent literature and expert opinion. This is by no means an exhaustive list.

Legal and Regulation Status

- Future data protection legislation is making provision for the digital age. Ireland will come in line with data protection reform across the 28 EU member states and Iceland, Norway and Liechtenstein (Europa 2014; Hawkes, 2014). It is likely that individual consent will be required prior to obtaining personal information for research purposes going forward.
- The publication of the forthcoming Health Information Bill will be instrumental in ensuring the best use of health information going forward. The enactment of the Health Bill will made provision for HIQAs guiding principles for national data collections to become national standards. This includes the monitoring of Theme 8, Use of

Information, National Standard for Safer Better Care (HIQA 2012c; HIQA Correspondence Appendix 8.1).

- The HI Bill will also make provision for a unique health identifier for individuals, professionals and organisations (Government of Ireland 2013)
- HIQA's future licensing of healthcare facilities and growth in quality assurance function will have an impact on data quality in the future (Appendix 8.1).
- A likely introduction of "Quality Accounts" similar to New Zealand and the UK will be introduced to drive data quality. A quality account is defined as a quality of services report produced by healthcare providers. These reports are submitted under statutory duty, published annually and made available to the public (NHS UK 2014; Health Quality & Safety Commission New Zealand 2012).

Technical

- A robust e-health infrastructure, disruptive technologies, cloud computing and business intelligence will shape the future of data production and processing (HSE 2013; CSC 2010).
- The arrival of cloud based computing will take us beyond the tradition concerns of data accuracy. Dimensions such as accessibility, data integrity, provenance (data source), interpretability, trustworthiness and security are now becoming important quality measures (Almutiry et al 2013; Linder et al 2012).
- The future of large scale quality measurement probably lies with EHR-Based quality measurement that will be dependent on structured documentation. Improved quality of care can be attained through certain EHR-based features such as problem lists, audit trails, CDS and voice recognition software (Linder et al 2012; Cruz-Correia et al 2013).
- The development of technology to support on-going assessment of routinely collected administrative and healthcare data. The data quality assessment (DQA) tool, developed by the WHO is one such example (WHO 2014). This allows organisations to identify the level of data accuracy in their organisation through the generation of data quality reports cards.
- The widespread introduction of interoperability standards to support the EHR model in Ireland (the ultimate goal of eHealth) is being reviewed currently (HIQA, 2013c,d)

6.11 Conclusion

This discussion shows the aim of the study was met, based upon improvements in data quality across the surgical data set. Capturing the breadth and depth of data completeness facilitated the different intended uses. A high level of concordance between iPM and the theatre log book offers reassurance that the data is consistent and therefore is likely to have a high level of reliability. It is recommended that theatre staff transfer to electronic recording of theatre data, moving from dual recording.

Timeliness in confirming surgical procedures is important as delay may lead to inaccuracies or omissions. Conversely, advanced completion of the surgical produces may also lead to errors. Surgical procedure code confirmation is an important activity. Inaccurate or missing information diminishes the effect of theatre activity reporting and potentially resulting in medicolegal issues. Laterality specification is a patient safety issue, therefore greater efforts needs to be made to record this activity. Feedback from research findings was the principle method to motive data input, with success in two of the three measures.

The merits of combining research and TDQA methodology was successfully developed and can be replicated in other theatres. Secondary use of data is an understated resource and is underutilised in the clinical setting. It is however time consuming to repurpose data for research purposes. With the imminent arrival of “Big data”, data protection legislation will come in line to secure the privacy rights of individuals. New technology, ehealth and legislation bring new opportunities to review data quality measurement and render its suitability.

Chapter Seven Conclusion

7.1 Introduction to Conclusion

This concluding chapter will provide a summary of the main results linked to the aim and objectives of the study. The implications for further research and development are outlined along with the study limitations and a brief overall conclusion.

7.2 Research Summary

The purpose of this study was to assess and improve the quality of data in the theatre setting, which in turn will lead to improved patient care. This was successfully achieved as a comprehensive approach was used to assess the completeness, concordance and timeliness of the data. A strong theoretical and practical tool was designed to facilitate the measurement of data quality dimensions. The merging of two theoretical approaches, research and TDQA, made it possible to carry out the investigation and encompass data improvement. The end result was a higher quality data delivery to inform healthcare management and performance.

The aim of the study was to determine if quality measures, based on secondary use of data, lead to improvement in data quality. The results showed that this aim was achieved, as quality interventions based on secondary use of data did lead to a great number of improvements in data quality. Statistically significant improvement was found in the top 10% level of surgical record completeness and concordance, in seven completeness fields and in three concordance fields. There was also higher levels of agreement between completeness and concordance scores posttest. However, the study found no overall significant difference in data quality pretest-posttest. The Null hypothesis was accepted as the means scores for completeness (88% versus 92%, $p=0.1288$), concordance (84% versus 89%, $p=0.1105$) and timeliness (27% versus 24%, $p=0.3155$) did not reach a level of statistical significance set at $p<0.05$. The study also identified gaps in data quality and highlighted that procedure code confirmation, timeliness and laterality specification needs further review. Several clinically important issues were raised, supporting the recommendation of moving to a paperless system.

7.3 Implications for Research and Development

- The quality dimensions used in the study were seen as the most important for measuring data quality in the study hospital theatre setting. It is recommended

that these measures are repeated in other theatres and that structure are put in place for ongoing data quality measurement.

- This study demonstrates that secondary use of data, presented in the correct format, can be an effective motivator to improve the quality of data. However, the dependence on manual data abstraction and the time taken to report data for secondary use makes it an unattractive solution. This is an areas requiring further discussion and investigation.
- A number of gaps in data quality were identified. While the research and feedback technique successfully motivated a cohort of clinicians, it is suggested that further work is required on motivational theory and the use of quality improvement tools to enhance IT usage in an Irish setting.
- The researcher would strongly recommend the use of SWOT analysis and KPIs to motivate continuous improvement in data quality. However larger studies are required in this area.
- Effective documentation is important to support patient's quality of care, not only at the time of surgery, but in the follow-up period. It is important therefore that regular audit and feedback of data quality continues, and that it is given management support and the resources to undertake this necessary work.
- The finding in this study are very positive for completeness and concordance, therefore clinicians can have confidence in their data if the current level of recording is maintained and improved in the areas highlighted. It is recommended that clinicians consider moving to the sole use electronic data.
- Despite the very large volume of data quality literature, there is a paucity of pre/post design. Further large scale studies are required in this area.

7.4 Study Limitations

A number of limitation were identified. However, these limitations do not deflect from the usefulness of the study.

- The mapping of procedure coding was not fully completed at the time of the study, which may have adversely affected data completion and concordance rates.
- The study was conducted over a short timeframe. It is feasible that a more statistically significant result would have been achieved with a larger sample size and more time to implement the quality interventions.

- The study was based on the data of one electronic system at a single healthcare institution and in one theatre, therefore the results may not be generalizable to other organisations.
- The measurement of data quality was confined to three data dimensions. These particular measures may not be suitable to the needs of other care settings.
- The instruments scoring has not been tested outside the current environment, therefore, further validation is required.
- The theatre log book was set as the gold standard. There was an inability to validate the accuracy of this retrospective data, therefore in some instances the electronic record may have been more accurate.

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7.5 Research Conclusion

The quality of healthcare data should to be vigorously pursued as this underpins critical decisions making around patient care and the resources needed to deliver this care. The EHR, business intelligence and cloud computing are the future in monitoring healthcare activity, therefore secondary use of date in tandem with data quality is and will continue to be of paramount importance. With greater technological support and advancement, and appropriate leadership, the secondary use of data can improve data quality. To quote the words of leadership trainer John E Jones "*What gets measured gets done. What gets measured and fed back gets done well"* (Jones, 1996). This seems an apt way to conclude this study.

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Appendix 1 Ethics

Appendix 1.1 Ethical Approval Trinity College Dublin

School of Computer Science and Statistics
Research Ethical Application Form

Part A

Project Title: An investigation into the use of secondary electronic data to address data quality in a theatre setting.

Name of Lead Researcher (student in case of project work): Ann Kelleher Keane (Student No 12327821)

Name of Supervisor: Mary Sharp, Assistant Professor, Lecturer and Tutor, School of Computer Science and Statistics, Trinity College Dublin

TCD E-mail: kcanen8@tcd.ie Contact Tel No.: 087 0975859

Course Name and Code (if applicable): MSc in Health Informatics
Estimated start date of survey/research: 13th January 2014

I confirm that I will (where relevant):

- Familiarize myself with the Data Protection Act and the College Good Research Practice guidelines http://www.tcd.ie/info_compliance/ethics/policies.php;
- Tell participants that any recordings, e.g. audio/video/photographs, will not be identifiable unless prior written permission has been given. I will obtain permission for specific reuse (in papers, talks, etc.)
- Provide participants with an information sheet (or web page for web-based experiments) that describes the main procedures (a copy of the information sheet must be included with this application)
- Obtain informed consent for participation (a copy of the informed consent form must be included with this application)
- Should the research be observational, ask participants for their consent to be observed
- Tell participants that their participation is voluntary
- Tell participants that they may withdraw at any time and for any reason without penalty
- Give participants the option of omitting questions they do not wish to answer if a questionnaire is used
- Tell participants that their data will be treated with full confidentiality and that, if published, it will not be identified as theirs
- On request, debrief participants at the end of their participation (i.e. give them a brief explanation of the study)
- Verify that participants are 18 years or older and competent to supply consent.
- If the study involves participants viewing video displays then I will verify that they understand that if they or anyone in their family has a history of epilepsy then the participant is proceeding at their own risk
- Declare any potential conflict of interest to participants.
- Inform participants that in the extremely unlikely event that illicit activity is reported to me during the study I will be obliged to report it to appropriate authorities.
- Act in accordance with the information provided (i.e. if I tell participants I will not do something, then I will not do it).

Signed: Date: 07/01/2014
Lead Researcher/student in case of project work

Part B

Please answer the following questions.		*Yes/No*
Has this research application or any application of a similar nature connected to this research project been refused ethical approval by another review committee of the College (or at the institutions of any collaborators)?		No
Will your project involve photographing participants or electronic audio or video recordings?		No
Will your project deliberately involve misleading participants in any way?		No
Is there a risk of participants experiencing either physical or psychological distress or discomfort? If yes, give details on a separate sheet and state what you will tell them to do if they should experience any such problems (e.g. who they can contact for help).		No
Does your study involve any of the following?	Children (under 18 years of age)	No
	People with intellectual or communication difficulties	No
	Patients	Yes

School of Computer Science and Statistics
Research Ethical Application Form

Details of the Research Project Proposal must be submitted as a separate document to include the following information:

1. Title of project
2. Purpose of project including academic rationale
3. Brief description of methods and measurements to be used
4. Participants - recruitment methods, number, age, gender, exclusion/inclusion criteria, including statistical justification for numbers of participants
5. Debriefing arrangements
6. A clear concise statement of the ethical considerations raised by the project and how you intend to deal with them
7. Cite any relevant legislation relevant to the project with the method of compliance e.g. Data Protection Act etc.

Part C

I confirm that the materials I have submitted provided a complete and accurate account of the research I propose to conduct in this context, including my assessment of the ethical ramifications.

Signed: Aoife Kelleher Keane Date: 7/01/2014
Lead Researcher/student in case of project work

There is an obligation on the lead researcher to bring to the attention of the SCSS Research Ethics Committee any issues with ethical implications not clearly covered above.

Part D

If external ethical approval has been received, please complete below.

External ethical approval has been received and no further ethical approval is required from the School's Research Ethical Committee. I have attached a copy of the external ethical approval for the School's Research Unit.

Signed: Aoife Kelleher Keane Date: 7/01/2014
Lead Researcher/student in case of project work

Part E

If the research is proposed by an undergraduate or postgraduate student, please have the below section completed.

I confirm, as an academic supervisor of this proposed research that the documents at hand are complete (i.e. each item on the submission checklist is accounted for) and are in a form that is adequate for review by the SCSS Research Ethics Committee

Signed: Date: 7/1/14
Supervisor

Completed application forms together with supporting documentation should be submitted electronically to research-ethics@scss.tcd.ie Please use TCD e-mail addresses only. When your application has been reviewed and approved by the Ethics committee hardcopies with original signatures should be submitted to the School of Computer Science & Statistics, Room F37, O'Reilly Institute, Trinity College, Dublin 2.

Appendix 2 Tables

Appendix 2.1 Completeness Scores Pretest

Surgical Procedure (Electronic) Completeness Pretest																			
	Administrative Data							Procedure								Team			
			Patients Name																
Record No (n=70)	Operative Description	MRN	Forename	Surname	Date of Birth	Speciality	Theatre Name	Date of Surgery (Dttm)	Into Theatre (hr:min)	Surgery Start (hr:min)	Surgery Complete (hr : min)	Surgical Procedure Name	Laterality of Surgical Procedure	Surgical Procedure Code Confirmed	Out of Theatre (hr:min)	Consultant Name	Staff Present	Role Description	Total Completeness Score %
1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.88	0.88	0.99
2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	1.00	1.00	1.00	0.89
3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	0.00	1.00	1.00	1.00	1.00	0.89
4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	1.00	0.80	0.80	0.87
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	NA	0.00	1.00	1.00	0.88	0.88	0.85
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	0.00	1.00	1.00	0.86	0.86	0.87
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	1.00	0.86	0.86	0.87
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00	0.94
9	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	0.00	1.00	1.00	0.80	0.80	0.87
10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.86	0.86	0.93
11	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	0.94
12	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	0.00	0.00	1.00	1.00	0.78	0.78	0.84
13	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	1.00	1.00	1.00	0.89
14	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	1.00	1.00	1.00	0.89
15	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	1.00	0.86	0.86	0.87
16	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.83	0.83	0.93
17	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	1.00	0.00	1.00	1.00	0.80	0.80	0.81
18	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	1.00	1.00	0.00	1.00	0.63	0.63	0.79
19	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	1.00	1.00	1.00	0.71	0.71	0.91
20	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	0.00	1.00	1.00	0.63	0.63	0.85
21	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	0.00	0.00	1.00	1.00	0.86	0.86	0.85
22	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	0.00	1.00	1.00	0.75	0.75	0.86
23	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	1.00	NA	0.00	0.00	1.00	0.00	0.00	0.50
24	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	1.00	0.83	0.83	0.87
25	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	1.00	1.00	1.00	0.60	0.60	0.90
26	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	1.00	1.00	1.00	0.89
27	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.25	0.25	0.92
28	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.88	0.88	0.93
29	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	1.00	1.00	1.00	0.67	0.67	0.91
30	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	NA	1.00	1.00	1.00	0.86	0.86	0.90
31	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	1.00	0.67	0.67	0.85
32	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	0.00	0.00	1.00	1.00	0.75	0.75	0.83
33	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.78	0.78	0.92
34	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.71	0.71	0.97
35	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	NA	1.00	1.00	1.00	0.86	0.86	0.90
36	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	1.00	1.00	1.00	0.83	0.83	0.93
37	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.75	0.75	0.92
38	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.86	0.86	0.87
39	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	0.00	1.00	1.00	0.86	0.86	0.87
40	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	0.00	0.00	1.00	1.00	0.86	0.86	0.85
41	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	0.00	0.00	1.00	1.00	0.60	0.60	0.82
42	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	0.00	1.00	0.00	1.00	1.00	0.83
43	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	0.00	1.00	1.00	0.71	0.71	0.86
44	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.67	0.67	0.85
45	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	1.00	0.88	0.88	0.88
46	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	0.00	1.00	1.00	1.00	1.00	0.89
47	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.80	0.80	0.92
48	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00	0.94
49	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	0.00	0.00	1.00	1.00	0.71	0.71	0.83
50	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	NA	0.00	0.00	1.00	0.67	0.67	0.69
51	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.86	0.86	0.98
52	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	1.00	0.83	0.83	0.87
53	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	1.00	0.83	0.83	0.87
54	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.50	1.00	0.00	1.00	1.00	1.00	1.00	0.86
55	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	0.00	0.83	0.83	0.81
56	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.83	0.83	0.98
57	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	NA	1.00	0.00	1.00	0.67	0.67	0.80
58	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	1.00	1.00	1.00	0.00	0.00	0.83
59	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.88	0.88	0.93
60	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.86	0.86	0.93
61	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.88	0.88	0.93
62	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	1.00	0.88	0.88	0.88
63	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	0.94
64	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	0.00	1.00	1.00	1.00	0.67	0.67	0.88
65	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	1.00	1.00	1.00	0.75	0.75	0.92
66	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.57	0.57	0.95
67	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	1.00	1.00	1.00	0.83	0.83	0.93
68	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	1.00	1.00	1.00	0.88	0.88	0.93
69	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.88	0.88	0.93
70	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	0.00	1.00	1.00	0.38	0.38	0.82
sum	69	70	70	70	70	70	70	70	66	66	65	64.5	12	32	66	68	55.08	55.08	61.59
mean	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.94	0.94	0.93	0.92	0.26	0.46	0.94	0.97	0.79	0.79	0.8799
SD	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.2354	0.2354	0.2612	0.1833	0.4440	0.5018	0.2338	0.1678	0.196717	0.1967	

Appendix 2.2 Concordance Scores Pretest

Surgical Record Concordance (Theatre Log and Electronic Data) Pretest																
	Administrative Data							Procedure					Team			
			Patients Name													
Record No (n=70)	Operative Type	MRN	Forename	Surname	Date of Birth	Speciality	Theatre Name	Date of Surgery (Dttm)	Into Theatre (hr:min)	Surgical Procedure Name	Laterality of Surgical Procedure	Out of Theatre (hr:min)	Consultant Name	Staff Present	Role Description	Total Concordance Score %
1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	0.88	0.88	0.92
2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00	0.93
3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	NA	1.00	1.00	1.00	1.00	0.87
4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.57	0.80	0.89
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	NA	1.00	1.00	0.70	0.88	0.87
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	1.00	1.00	0.67	0.86	0.90
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.63	0.86	0.90
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.56	1.00	0.97
9	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	1.00	1.00	0.57	0.80	0.82
10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.75	0.86	0.91
11	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00	0.93
12	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	0.00	1.00	1.00	0.78	0.78	0.87
13	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	1.00	1.00	1.00	0.80
14	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.86	0.92
15	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.75	0.71	0.90
16	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.63	0.83	0.90
17	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	1.00	0.00	1.00	0.57	0.67	0.85
18	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	0.63	0.63	0.82
19	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	1.00	1.00	0.63	0.71	0.89
20	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	NA	1.00	0.00	0.56	0.63	0.75
21	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	0.00	1.00	1.00	0.86	0.71	0.87
22	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	0.00	1.00	0.75	0.63	0.83
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	NA	0.00	0.00	0.00	0.00	0.07
24	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	0.63	0.83	0.83
25	0.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	0.00	1.00	NA	0.00	1.00	0.60	0.60	0.61
26	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.88	1.00	0.93
27	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.25	0.95
28	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.88	1.00	0.93
29	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	1.00	1.00	0.57	0.67	0.88
30	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.50	NA	1.00	1.00	0.86	0.86	0.81
31	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	0.71	0.67	0.83
32	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	0.00	1.00	0.00	1.00	0.75	0.82
33	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	1.00	0.78	0.78	0.77
34	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	0.71	0.71	0.90
35	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	NA	0.00	1.00	0.75	0.75	0.80
36	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	1.00	1.00	0.63	1.00	0.91
37	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	0.75	0.75	0.83
38	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	0.00	1.00	1.00	0.67	0.86	0.77
39	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	NA	0.00	1.00	0.75	0.86	0.81
40	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	0.00	1.00	1.00	0.86	0.86	0.81
41	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	0.00	1.00	0.00	0.50	1.00	0.80
42	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	1.00	0.00	0.63	0.83	0.83
43	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	1.00	0.00	0.63	0.71	0.82
44	1.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	0.00	1.00	1.00	0.44	0.83	0.75
45	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	0.88	0.88	0.78
46	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	NA	0.00	1.00	0.67	1.00	0.78
47	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.83	0.80	0.91
48	0.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00	1.00	0.63	1.00	0.78
49	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.50	0.00	1.00	1.00	0.71	0.71	0.80
50	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	0.00	1.00	0.67	0.44	0.74
51	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.75	0.86	0.84
52	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.83	0.67	0.90
53	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	1.00	0.83	0.83	0.84
54	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.50	0.00	1.00	1.00	0.86	1.00	0.76
55	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	0.00	0.63	0.67	0.75
56	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.63	0.83	0.90
57	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	0.00	1.00	0.75	0.75	0.83
58	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	0.00	1.00	0.00	0.00	0.67
59	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	0.00	1.00	1.00	0.67	0.56	0.85
60	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.75	0.75	0.90
61	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.88	0.88	0.92
62	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	0.88	0.88	0.85
63	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	0.75	1.00	0.85
64	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.67	0.67	0.89
65	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	1.00	1.00	0.75	0.75	0.90
66	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	0.44	0.57	0.80
67	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	0.00	1.00	0.71	0.83	0.84
68	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	1.00	1.00	1.00	0.88	0.93
69	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.88	0.75	0.91
70	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	1.00	1.00	0.38	0.38	0.85
sum	57.00	68.00	69.00	69.00	69.00	69.00	65.00	70.00	63.00	57.50	6.00	48.00	63.00	50.05	53.96	58.50
mean	0.81	0.97	0.99	0.99	0.99	0.99	0.93	1.00	0.90	0.82	0.13	0.69	0.90	0.72	0.77	0.8357
SD	0.3917	0.1678	0.1195	0.1195	0.1195	0.1195	0.2594	0	0.3022	0.3189	0.3405	0.4676	0.3022	0.1924	0.2027	

Appendix 2.3 Timeliness Score Pretest

Timeliness of Surgical Procedures Confirmation Pretest	
Record No (n=70)	Surgical Procedure Code Confirm Time
1	1.00
2	0.00
3	0.00
4	0.00
5	0.00
6	0.00
7	0.00
8	0.00
9	0.00
10	0.50
11	0.50
12	0.00
13	0.00
14	0.00
15	0.00
16	0.50
17	0.00
18	0.00
19	1.00
20	0.00
21	0.00
22	0.00
23	0.00
24	0.00
25	0.00
26	0.00
27	0.50
28	1.00
29	0.50
30	1.00
31	0.00
32	0.00
33	0.00
34	0.00
35	0.50
36	1.00
37	0.50
38	0.00
39	0.00
40	0.00
41	0.00
42	0.00
43	0.00
44	1.00
45	0.00
46	0.00
47	0.50
48	0.00
49	0.00
50	0.00
51	1.00
52	0.00
53	0.00
54	0.00
55	0.00
56	1.00
57	0.00
58	0.00
59	1.00
60	1.00
61	1.00
62	0.00
63	1.00
64	0.05
65	0.50
66	1.00
67	0.50
68	0.50
69	0.00
70	0.00
Sum	18.55
Mean	0.27
SD	0.3963

Legend

- Confirmed before surgery completion
- Confirmed before surgry complete, within 10% Rule
- Confirmed after surgery completion

Appendix 2.4 Completeness Scores Posttest

Surgical Record (Electronic Record) Completeness Posttest																			
	Administrative Data							Procedure								Team			
			Patients Name																
Record No n=78	Operative Description	MRN	Forename	Surname	Date of Birth	Speciality	Theatre Name	Date of Surgery (Dttm)	Into Theatre (hr:min)	Surgery Start (hr:min)	Surgery Complete (hr : min)	Surgical Procedure Name	Laterality of Surgical Procedure	Surgical Procedure Code Confirmed	Out of Theatre (hr:min)	Consultant Name	Theatre Staff Present	Role Description	Total Completeness Score %
1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	0.00	1.00	1.00	1.00	1.00	0.89
2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	1.00	1.00	1.00	0.89
3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	1.00	1.00	1.00	0.88	0.88	0.93
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	0.94
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	1.00	1.00	1.00	1.00	1.00	0.94
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	0.00	1.00	1.00	0.83
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.67	0.67	0.91
9	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	1.00	0.86	0.86	0.87
10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.89	0.89	0.93
11	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	1.00	0.86	0.86	0.87
12	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
13	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	1.00	1.00	1.00	1.00	1.00	0.94
14	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	0.00	1.00	1.00	1.00	1.00	0.89
15	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.88	0.88	0.93
16	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	0.00	1.00	1.00	0.86	0.86	0.87
17	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.71	0.71	0.91
18	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	1.00	1.00	1.00	0.88	0.88	0.93
19	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	1.00	1.00	1.00	0.86	0.86	0.93
20	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00	0.94
21	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00	0.94
22	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	1.00	1.00	1.00	1.00	1.00	0.94
23	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	1.00	1.00	1.00	0.89	0.89	0.93
24	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00	0.94
25	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	1.00	1.00	1.00	0.89
26	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	0.00	1.00	1.00	0.86	0.86	0.87
27	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.86	0.86	0.93
28	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	0.00	0.00	1.00	1.00	0.83	0.83	0.84
29	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	0.00	1.00	1.00	0.57	0.57	0.84
30	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.78	0.78	0.92
31	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	1.00	0.86	0.86	0.87
32	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	0.00	1.00	1.00	1.00	1.00	0.89
33	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	0.94
34	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.71	0.71	0.97
35	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.33	NA	1.00	1.00	1.00	0.80	0.80	0.89
36	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	1.00	0.67	0.67	0.85
37	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	1.00	0.44	0.44	0.83
38	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	0.00	0.00	1.00	1.00	0.88	0.88	0.85
39	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	0.00	1.00	1.00	1.00	1.00	0.89
40	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	1.00	1.00	1.00	0.89
41	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	0.00	1.00	1.00	0.63	0.63	0.85
42	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	1.00	1.00	1.00	1.00	1.00	0.94
43	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	1.00	1.00	1.00	1.00	1.00	0.94
44	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.88	0.88	0.99
45	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	1.00	1.00	1.00	0.88	0.88	0.93
46	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	1.00	1.00	1.00	0.78	0.78	0.95
47	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.83	0.83	0.98
48	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	NA	1.00	1.00	1.00	0.83	0.83	0.90
49	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	0.00	1.00	1.00	0.75	0.75	0.89
50	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	0.00	1.00	1.00	0.86	0.86	0.87
51	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	1.00	0.86	0.86	0.87
52	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	NA	0.00	1.00	1.00	0.57	0.57	0.81
53	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	1.00	1.00	1.00	1.00	1.00	1.00	0.97
54	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	1.00	1.00	1.00	1.00	1.00	0.94
55	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
56	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	1.00	1.00	1.00	1.00	1.00	0.94
57	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00	0.94
58	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	0.00	1.00	1.00	1.00	1.00	0.92
59	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00	0.94
60	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.33	0.00	1.00	1.00	0.78	0.78	0.88
61	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	1.00	1.00	1.00	0.88	0.88	0.93
62	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	1.00	1.00	1.00	1.00	0.83	0.83	0.95
63	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.86	0.86	0.93
64	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	0.00	1.00	1.00	1.00	1.00	0.89
65	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	0.00	1.00	1.00	1.00	1.00	0.89
66	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	1.00	1.00	1.00	1.00	1.00	0.94
67	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	1.00	1.00	1.00	1.00	1.00	0.94
68	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	0.94
69	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	0.00	0.00	1.00	1.00	1.00	1.00	0.86
70	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	1.00	1.00	1.00	1.00	1.00	0.94
71	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	0.00	1.00	1.00	1.00	1.00	0.89
72	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	1.00	1.00	1.00	1.00	1.00	0.94
73	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	1.00	1.00	1.00	0.89
74	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	0.00	1.00	1.00	0.83	0.83	0.87
75	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	1.00	1.00	1.00	1.00	0.71	0.71	0.94
76	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.80	0.80	0.92
77	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	NA	0.00	1.00	1.00	0.88	0.88	0.85
78	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	NA	0.00	1.00	1.00	0.71	0.71	0.83
sum	78.00	78.00	78.00	78.00	78.00	78.00	78.00	78.00	78.00	78.00	78.00	72.33	21.83	34.00	78.00	77.00	69.60	69.60	72.14
mean	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.93	0.51	0.44	1.00	0.99	0.89	0.89	0.9249
SD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1815	0.4824631	0.4991	0.00	0.1132	0.1271	0.1271	

Appendix 2.5 Concordance Scores Posttest

Surgical Record (Electronic Record) Completeness Posttest																			
	Administrative Data							Procedure								Team			
			Patients Name																
Record No n=78	Operative Description	MRN	Forename	Surname	Date of Birth	Speciality	Theatre Name	Date of Surgery (Dttm)	Into Theatre (hr:min)	Surgery Start (hr:min)	Surgery Complete (hr : min)	Surgical Procedure Name	Laterality of Surgical Procedure	Surgical Procedure Code Confirmed	Out of Theatre (hr:min)	Consultant Name	Theatre Staff Present	Role Description	Total Completeness Score %
1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	0.00	1.00	1.00	1.00	1.00	0.89
2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	1.00	1.00	1.00	0.89
3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	1.00	1.00	1.00	0.88	0.88	0.93
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	0.94
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	1.00	1.00	1.00	1.00	1.00	0.94
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	0.00	1.00	1.00	0.83
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.67	0.67	0.91
9	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	1.00	0.86	0.86	0.87
10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.89	0.89	0.93
11	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	1.00	0.86	0.86	0.87
12	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
13	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	1.00	1.00	1.00	1.00	1.00	0.94
14	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	0.00	1.00	1.00	1.00	1.00	0.89
15	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.88	0.88	0.93
16	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	0.00	1.00	1.00	0.86	0.86	0.87
17	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.71	0.71	0.91
18	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	1.00	1.00	1.00	0.88	0.88	0.93
19	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	1.00	1.00	1.00	0.86	0.86	0.93
20	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00	0.94
21	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00	0.94
22	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	1.00	1.00	1.00	1.00	1.00	0.94
23	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	1.00	1.00	1.00	0.89	0.89	0.93
24	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00	0.94
25	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	1.00	1.00	1.00	0.89
26	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	0.00	1.00	1.00	0.86	0.86	0.87
27	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.86	0.86	0.93
28	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	0.00	0.00	1.00	1.00	0.83	0.83	0.84
29	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	0.00	1.00	1.00	0.57	0.57	0.84
30	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.78	0.78	0.92
31	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	1.00	0.86	0.86	0.87
32	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	0.00	1.00	1.00	1.00	1.00	0.89
33	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	0.94
34	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.71	0.71	0.97
35	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.33	NA	1.00	1.00	1.00	0.80	0.80	0.89
36	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	1.00	0.67	0.67	0.85
37	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	1.00	0.44	0.44	0.83
38	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	0.00	0.00	1.00	1.00	0.88	0.88	0.85
39	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	0.00	1.00	1.00	1.00	1.00	0.89
40	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	1.00	1.00	1.00	0.89
41	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	0.00	1.00	1.00	0.63	0.63	0.85
42	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	1.00	1.00	1.00	1.00	1.00	0.94
43	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	1.00	1.00	1.00	1.00	1.00	0.94
44	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.88	0.88	0.99
45	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	1.00	1.00	1.00	0.88	0.88	0.93
46	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	1.00	1.00	1.00	0.78	0.78	0.95
47	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.83	0.83	0.98
48	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	NA	1.00	1.00	1.00	0.83	0.83	0.90
49	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	0.00	1.00	1.00	0.75	0.75	0.89
50	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	0.00	1.00	1.00	0.86	0.86	0.87
51	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	1.00	0.86	0.86	0.87
52	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	NA	0.00	1.00	1.00	0.57	0.57	0.81
53	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	1.00	1.00	1.00	1.00	1.00	1.00	0.97
54	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	1.00	1.00	1.00	1.00	1.00	0.94
55	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
56	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	1.00	1.00	1.00	1.00	1.00	0.94
57	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00	0.94
58	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	0.00	1.00	1.00	1.00	1.00	0.92
59	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00	0.94
60	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.33	0.00	1.00	1.00	0.78	0.78	0.88
61	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	1.00	1.00	1.00	0.88	0.88	0.93
62	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	1.00	1.00	1.00	1.00	0.83	0.83	0.95
63	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.86	0.86	0.93
64	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	0.00	1.00	1.00	1.00	1.00	0.89
65	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	0.00	1.00	1.00	1.00	1.00	0.89
66	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	1.00	1.00	1.00	1.00	1.00	0.94
67	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	1.00	1.00	1.00	1.00	1.00	0.94
68	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	0.94
69	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	0.00	0.00	1.00	1.00	1.00	1.00	0.86
70	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	1.00	1.00	1.00	1.00	1.00	0.94
71	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	0.00	1.00	1.00	1.00	1.00	0.89
72	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	1.00	1.00	1.00	1.00	1.00	0.94
73	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	1.00	1.00	1.00	0.89
74	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	NA	0.00	1.00	1.00	0.83	0.83	0.87
75	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	1.00	1.00	1.00	1.00	0.71	0.71	0.94
76	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.80	0.80	0.92
77	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	NA	0.00	1.00	1.00	0.88	0.88	0.85
78	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	NA	0.00	1.00	1.00	0.71	0.71	0.83
sum	78.00	78.00	78.00	78.00	78.00	78.00	78.00	78.00	78.00	78.00	78.00	72.33	21.83	34.00	78.00	77.00	69.60	69.60	72.14
mean	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.93	0.51	0.44	1.00	0.99	0.89	0.89	0.9249
SD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1815	0.4824631	0.4991	0.00	0.1132	0.1271	0.1271	

Appendix 2.6 Timeliness Score Posttest

Timeliness of Surgical Procedures Posttest	
Record No N=78	Surgical Procedure Code Confirm Time
1	0.00
2	0.00
3	0.50
4	0.50
5	1.00
6	1.00
7	0.00
8	0.00
9	0.00
10	0.00
11	0.00
12	1.00
13	0.50
14	0.00
15	0.00
16	0.00
17	0.00
18	0.50
19	1.00
20	0.00
21	0.00
22	0.50
23	0.00
24	0.00
25	0.00
26	0.00
27	0.00
28	0.00
29	0.00
30	0.00
31	0.00
32	0.00
33	0.00
34	0.00
35	0.00
36	0.00
37	0.00
38	0.00
39	0.00
40	0.00
41	0.00
42	0.50
43	0.50
44	0.50
45	0.50
46	1.00
47	0.50
48	0.00
49	0.00
50	0.00
51	0.00
52	0.00
53	1.00
54	1.00
55	0.00
56	1.00
57	0.00
58	0.00
59	0.00
60	0.00
61	0.00
62	0.00
63	0.00
64	0.00
65	0.00
66	0.50
67	1.00
68	1.00
69	0.00
70	1.00
71	0.00
72	0.50
73	0.00
74	0.00
75	1.00
76	0.50
77	0.00
78	0.00
Sum	18.50
Mean	0.24
SD	0.3771

Legend

- Confirmed Before Surgery Completion
- Confirmed before surgry complete, within 10% Rule
- Confirmed after surgery completion

Appendix 2.7 Laterality Tables

Laterality Specification Pretest					
		Laterality Complete			
Total	Laterality NA	Manual Coding	Pre-coded	Not Complete	Total
No of Procedures	24	2	10	34	70
	34.29%	2.86%	14.29%	48.57%	100.00%

Laterality Specification Posttest					
		Laterality Complete			
Total	Laterality NA	Manual	Pre-coded	Not Complete	Total
No of Procedures	35	2	22	19	78
	44.87%	2.56%	28.21%	24.36%	100.00%

Appendix 2.8 Total Surgical Record Completeness

Total Surgical Record Completeness Pretest-Posttest				
	Pretest		Posttest	
Record No	Total Surgical Record Completeness Pretest %	Records Score > 89%	Total Surgical Record Completeness Posttest %	Record Score > 89%
1	0.99	1	0.89	0
2	0.89	0	0.89	0
3	0.89	0	1.00	1
4	0.87	0	0.93	1
5	0.85	0	0.94	1
6	0.87	0	0.94	1
7	0.87	0	0.83	0
8	0.94	1	0.91	1
9	0.87	0	0.87	0
10	0.93	1	0.93	1
11	0.94	1	0.87	0
12	0.84	0	1.00	1
13	0.89	0	0.94	1
14	0.89	0	0.89	0
15	0.87	0	0.93	1
16	0.93	1	0.87	0
17	0.81	0	0.91	1
18	0.79	0	0.93	1
19	0.91	1	0.93	1
20	0.85	0	0.94	1
21	0.85	0	0.94	1
22	0.86	0	0.94	1
23	0.50	0	0.93	1
24	0.87	0	0.94	1
25	0.90	1	0.89	0
26	0.89	0	0.87	0
27	0.92	1	0.93	1
28	0.93	1	0.84	0
29	0.91	1	0.84	0
30	0.90	1	0.92	1
31	0.85	0	0.87	0
32	0.83	0	0.89	0
33	0.92	1	0.94	1
34	0.97	1	0.97	1
35	0.90	1	0.89	0
36	0.93	1	0.85	0
37	0.92	1	0.83	0
38	0.87	0	0.85	0
39	0.87	0	0.89	0
40	0.85	0	0.89	0
41	0.82	0	0.85	0
42	0.83	0	0.94	1
43	0.86	0	0.94	1
44	0.85	0	0.99	1
45	0.88	0	0.93	1
46	0.89	0	0.95	1
47	0.92	1	0.98	1
48	0.94	1	0.90	1
49	0.83	0	0.89	0
50	0.69	0	0.87	0
51	0.98	1	0.87	0
52	0.87	0	0.81	0
53	0.87	0	0.97	1
54	0.86	0	0.94	1
55	0.81	0	1.00	1
56	0.98	1	0.94	1
57	0.80	0	0.94	1
58	0.83	0	0.92	1
59	0.93	1	0.94	1
60	0.93	1	0.88	0
61	0.93	1	0.93	1
62	0.88	0	0.95	1
63	0.94	1	0.93	1
64	0.88	0	0.89	0
65	0.92	1	0.89	0
66	0.95	1	0.94	1
67	0.93	1	0.94	1
68	0.93	1	0.94	1
69	0.93	1	0.86	0
70	0.82	0	0.94	1
71			0.89	0
72			0.94	1
73			0.89	0
74			0.87	0
75			0.94	1
76			0.92	1
77			0.85	0
78			0.83	0
sum	61.59	29	72.13	45
mean	0.88	0.4143	0.92	0.5769

Appendix 2.9 Total Surgical Record Concordance

Total Surgical Record Concordance Pretest-Posttest				
	Pretest		Posttest	
Record No	Total Surgical Record Concordance Pretest %	Records Score > 89%	Total Surgical Record Concordance Posttest %	Record Score > 89%
1	0.92	1	0.93	1
2	0.93	1	0.87	0
3	0.87	0	1.00	1
4	0.89	0	0.84	0
5	0.87	0	0.93	1
6	0.90	1	0.93	1
7	0.90	1	0.93	1
8	0.97	1	0.86	0
9	0.82	0	0.70	0
10	0.91	1	0.99	1
11	0.93	1	0.78	0
12	0.87	0	0.93	1
13	0.80	0	0.93	1
14	0.92	1	0.93	1
15	0.90	1	0.88	0
16	0.90	1	0.83	0
17	0.85	0	0.68	0
18	0.82	0	0.90	1
19	0.89	0	0.87	0
20	0.75	0	0.98	1
21	0.87	0	0.99	1
22	0.83	0	0.93	1
23	0.07	0	0.91	1
24	0.83	0	0.99	1
25	0.61	0	0.78	0
26	0.93	1	0.90	1
27	0.95	1	0.91	1
28	0.93	1	0.79	0
29	0.88	0	0.87	0
30	0.81	0	0.89	0
31	0.83	0	0.85	0
32	0.82	0	0.86	0
33	0.77	0	0.93	1
34	0.90	1	0.89	0
35	0.80	0	0.77	0
36	0.91	1	0.88	0
37	0.83	0	0.93	1
38	0.77	0	0.88	0
39	0.81	0	0.92	1
40	0.81	0	0.89	0
41	0.80	0	0.81	0
42	0.83	0	0.86	0
43	0.82	0	0.93	1
44	0.75	0	0.98	1
45	0.78	0	0.91	1
46	0.78	0	0.90	1
47	0.91	1	0.96	1
48	0.78	0	0.86	0
49	0.80	0	0.92	1
50	0.74	0	0.81	0
51	0.84	0	0.91	1
52	0.90	1	0.82	0
53	0.84	0	0.97	1
54	0.76	0	0.93	1
55	0.75	0	0.93	1
56	0.90	1	0.92	1
57	0.83	0	0.99	1
58	0.67	0	0.93	1
59	0.85	0	0.87	0
60	0.90	1	0.87	0
61	0.92	1	0.92	1
62	0.85	0	0.94	1
63	0.85	0	0.85	0
64	0.89	0	0.87	0
65	0.90	1	0.93	1
66	0.80	0	0.93	1
67	0.84	0	0.87	0
68	0.93	1	0.90	1
69	0.91	1	0.89	0
70	0.85	0	0.93	1
71			0.86	0
72			0.85	0
73			0.93	1
74			0.84	0
75			0.88	0
76			0.89	0
77			0.85	0
78			0.86	0
sum	58.50	23	70.53	45
mean	0.84	0.33	0.90	0.58

Appendix 3 Training Manual

Appendix 3.1 Training Manual

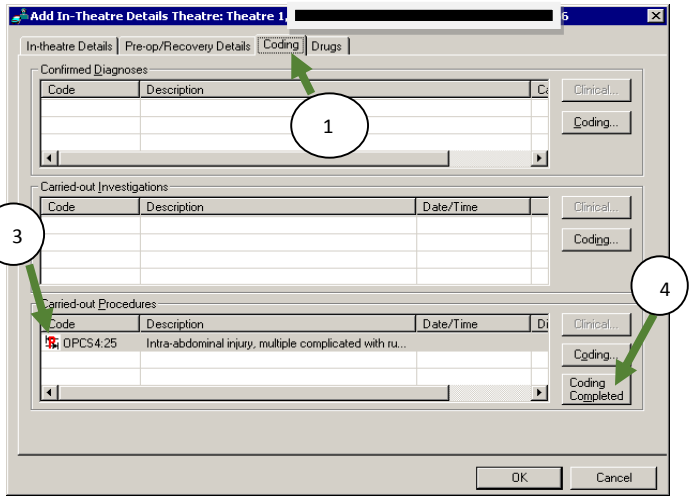
Completing Surgical Procedure Coding in the In-theatre details.

Coding

To complete **Procedure Coding** information1

When the procedure carried out matches the procedure displayed

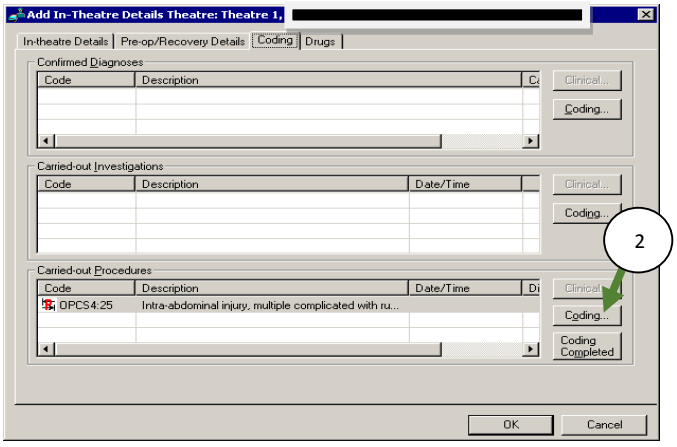
1. From In-Theatre Details click on the **Coding** Tab
2. The Coding options screen appears
3. The surgical procedure(s) is displayed in the **Carried-out Procedure** section
4. Click **Coding Completed**
5. **Click OK**

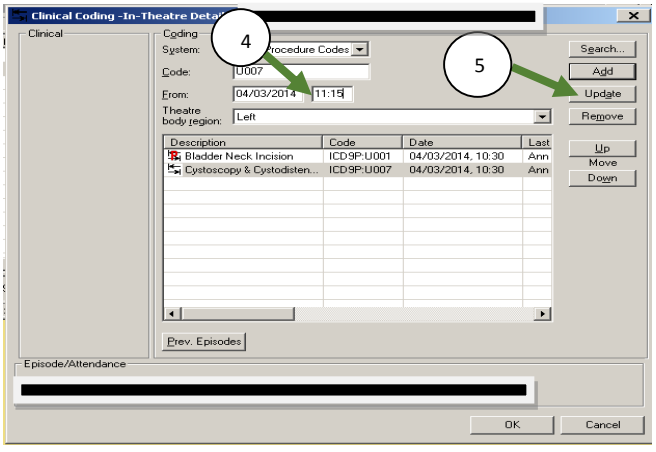


Updating the Confirmation Time of the Surgical Procedure

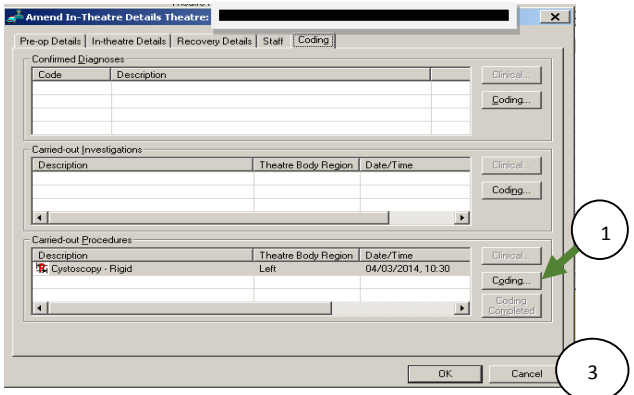
Coding to be complete before the patient leaves the theatre, clinical activity allowing.

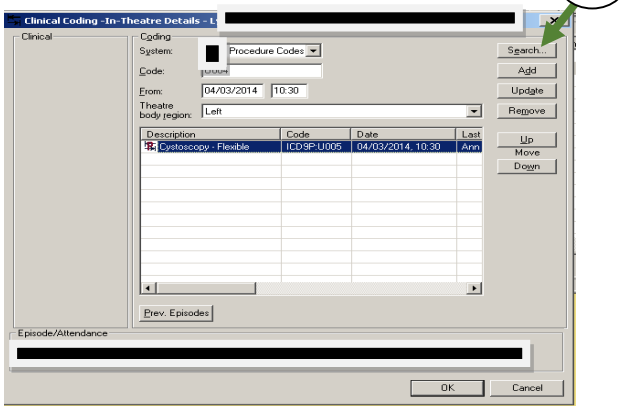
1. Go to Coding options screen
2. Click on Coding
3. This brings you to Clinical Coding In-Theatre details screen
4. Update time when the surgery is complete
5. Click **Update**
6. Click **OK**

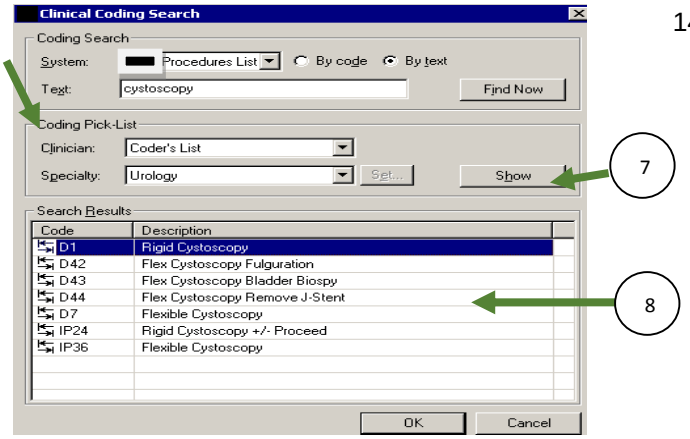




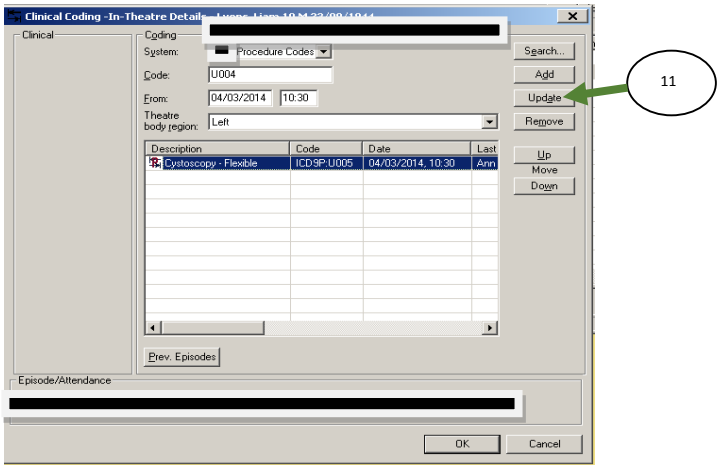
To CHANGE the surgical procedure displayed in the Carried Out Procedures window





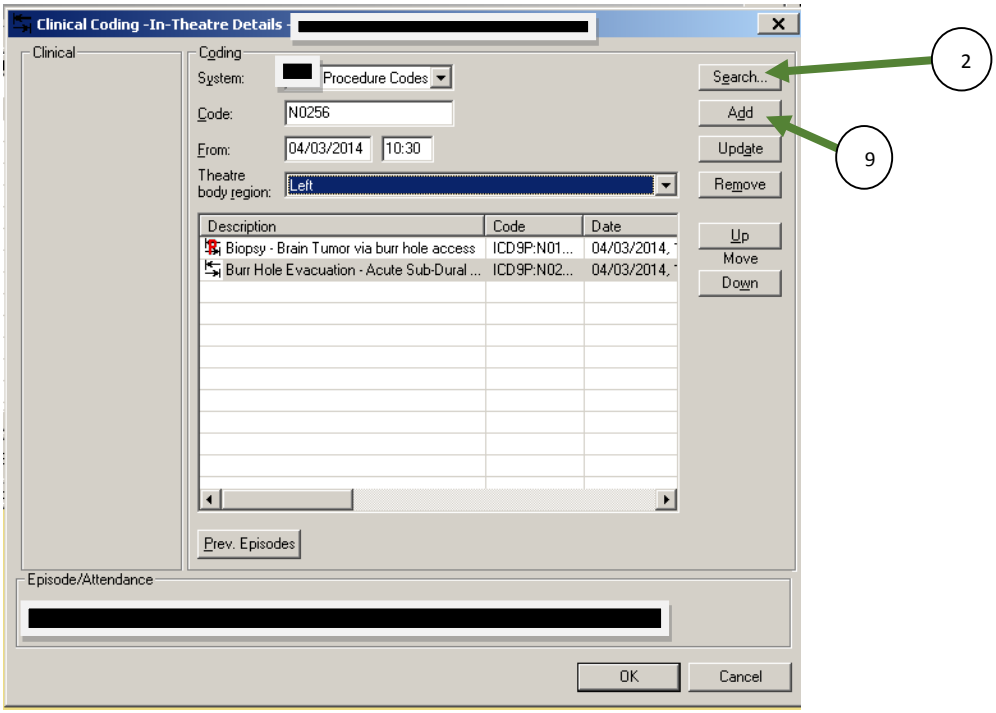


1. Click on **Coding** in the Coding options screen
2. **The Clinical Coding** screen will be displayed
3. Click on **Search**
4. The **Clinical Coding Search** Screen will be displayed
5. Go to **Coding Pick-list** Section
6. Select Speciality (ie., Urology)
7. Select **Show**
8. Select the required procedure from the Pick List Section
9. Click **Ok**
10. The Clinical Coding screen will appear
11. Click **Update**
12. Click **OK**
13. The Coding Options Screen will appear will the updated procedure
14. Click **Coding Completed**



To ADD ANOTHER PROCEDURE in the Carried Out Procedures pane

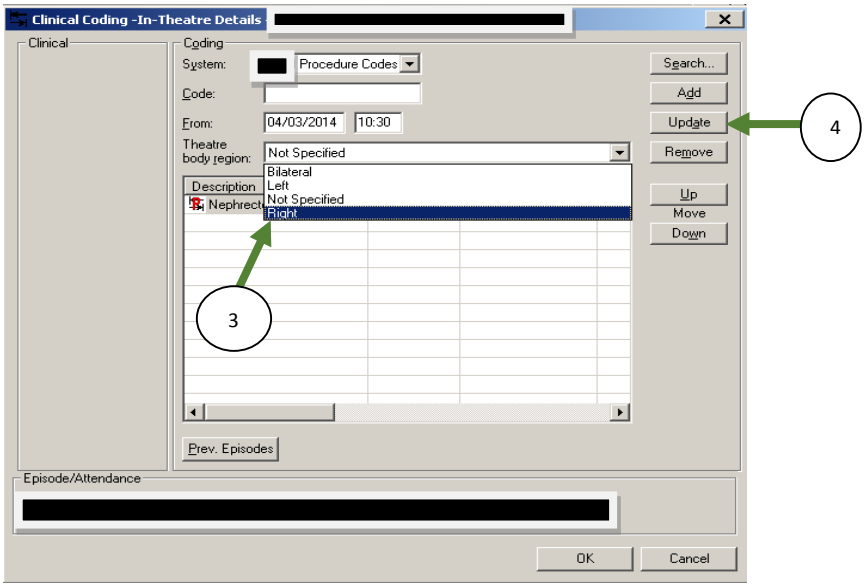
1. Click on **Coding** in the Coding Screen
2. The **Clinical Coding** screen will be displayed. Click on **Search**.
3. The **Clinical Coding Search** screen will be displayed
4. Go to **Coding-Pick List** Section
5. Select Speciality (ie., Urology)
6. Select **Show**
7. Select the procedure from the search results
8. Click **OK**
9. Click **Add**
10. Click **OK**
11. Click **Coding Completed**

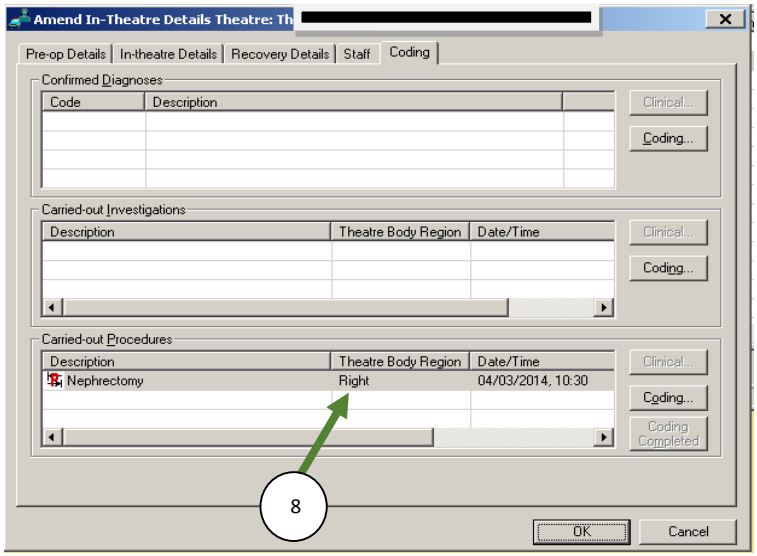


Laterality

When the surgery requires to be identified as having Left, Right or Bilateral orientation

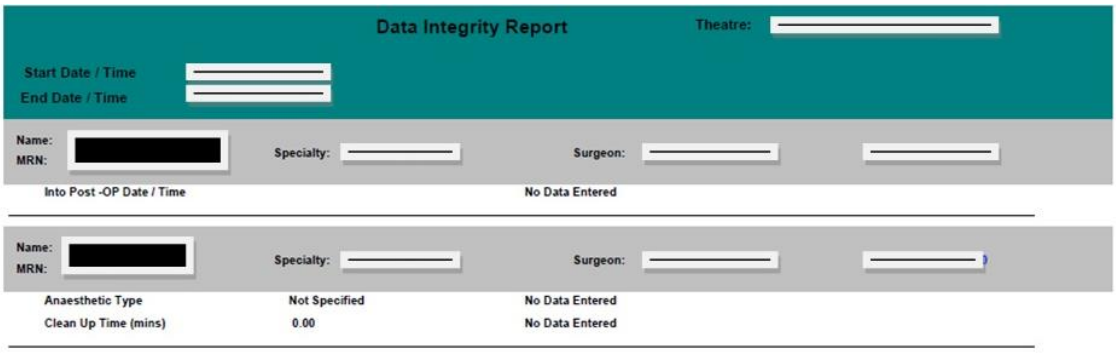
1. Click on **Coding** in the Coding Options Screen
2. The Clinical Coding screen will be displayed
3. Choose from one of the options in the **Theatre body region** section
4. Click **Update**
5. **Not Specified** will be displayed in the Theatre body region section
6. Click **OK**
7. This will bring you back to the In the Coding Tab
8. In the carried out procedures section, the selected laterality will be displayed under Theatre Body Region


Clinical Coding -In-Theatre Details
Clinical
Coding
System:
Procedure Codes
Code:
From:
04/03/2014
10:30
Theatre body region:
Not Specified
Bilateral
Left
Not Specified
Right
Description
Search...
Add
Update
Remove
Up
Move
Down
Prev. Episodes
Episode/Attendance
OK
Cancel
3
4


Amend In-Theatre Details Theatre: Th
Pre-op Details
In-theatre Details
Recovery Details
Staff
Coding
Confirmed Diagnoses
Code
Description
Clinical...
Coding...
Carried-out Investigations
Description
Theatre Body Region
Date/Time
Clinical...
Coding...
Carried-out Procedures
Description
Theatre Body Region
Date/Time
Nephrectomy
Right
04/03/2014, 10:30
Clinical...
Coding...
Coding Completed
OK
Cancel
8

Appendix 4 Data Integrity Report

Appendix 4.1 Data Integrity Report



Data Integrity Report

Theatre:

Start Date / Time

End Date / Time

Name:
MRN:

Specialty:

Surgeon:

Into Post -OP Date / Time		No Data Entered

Name:
MRN:

Specialty:

Surgeon:

Anaesthetic Type	Not Specified	No Data Entered
Clean Up Time (mins)	0.00	No Data Entered

Appendix 5 Product Alert Notice

Appendix 5.1 Product Alert Notice

Alert notice

Issue/v2.0

WARNING: This document is uncontrolled unless viewed electronically from its original location. Where an uncontrolled document is used it is the responsibility of the person using it to ensure that it is the latest version.

CSC Alert notice

CSC's clinical team is vigilant with regard to potential service issues that could impact upon patient safety. A CSC Alert notice is issued when we identify a risk to patient safety and identify that you should immediately adopt a work-around and a fix should be installed as a matter of urgency.

Listed below are details of the issue and if there is a workaround shown please put this into place immediately. It is also mandatory that you follow the 'next steps' (if provided) section below and implement the fix (as soon as available) as a matter of urgency. If you are a managed site, please request CSC to install the fix in the same way you request an install for any other fixes.

i.Patient Manager **Where patients have multiple procedures, ONLY the last laterality added is shown on various Theatre views.**			
Date		22 April 2014	
From		Andy Connelly, PAS Product Manager	
Product		i.Patient Manager	
Build	7	**Version**	3.0
Details		In the Theatre module, where patients have multiple procedures, ONLY the last laterality added will show on the following screens: 1) Theatre List View 2) Theatre Overview View 3) Theatre Manager View The Patient Record View>Theatre Booking node also shows the incorrect laterality, however this screen is not used in Theatre. The Coding screen within the Theatre view will show the correct procedure information.	
CSC's impact analysis		If the affected screens are used as the only source of information with regard to laterality, there is the potential for patients to have an operation to the incorrect side of their body.	
Constraint		Incorrect information is restricted to the following screens: 1) Theatre List View, 2) Theatre Overview View, 3) Theatre Manager View	
Workaround		CSC has identified a workaround by a change to a configuration setting which will prevent the incorrect data being displayed, and which will force users to check the coding screen for the correct laterality information. This workaround is to mitigate any risk in the short term.	

Alert notice

Issue/v2.0

Workaround	By removing the new value THEBR from the following list order profiles, Theatre Body Region will be removed from the screens below: LIST_ORDER_THLIST - Theatre List LIST_ORDER_THMAN - Theatre Manager LIST_ORDER_THOVIEW - Theatre Overview LIST_ORDER_THEAT_PRV - Patient Record View (Theatre booking node) This will force users to use the Coding tab to view the correct procedural information.
Proposed resolution	Correctly display each of the procedures with the correct laterality displayed.
Resolution available on	Version 3.1
CSC's nominated contacts	Please contact the CSC Customer Services Team via our Service Desk.
Next steps	Please apply the workaround by changing the configuration setting described above, which will prevent the incorrect data being displayed and which will force users to use the Coding tab to view the correct laterality information.

Please note: This may affect your practice if you use the Theatres module within your business processes.

Glossary of terms and abbreviations	
THEBR	Theatre Body Region

Appendix 6 Laterality

Appendix 6.1 Laterality

ICD-10 Coding for Ophthalmology (A New Chapter for Eyes, Nicoletti,B (2014) Disclosures February 21, 2014)

Laterality Code Example

Code	Condition
H01.111	Allergic dermatitis of right upper eyelid
H01.112	Allergic dermatitis of right lower eyelid
H01.113	Allergic dermatitis of right eye, unspecified eyelid
H01.114	Allergic dermatitis of left upper eyelid
H01.115	Allergic dermatitis of left lower eyelid
H01.116	Allergic dermatitis of left eye, unspecified eyelid
H01.119	Allergic dermatitis of unspecified eye, unspecified eyelid

April 2007 SEER Program Coding and Staging Manual 2007

PRIMARY SITES FOR WHICH REQUIRES LATERALITY INFORMATION

Laterality codes of '1'-'9' must be used for the following sites except where a specific subheading is excluded. Such exclusions are coded '0'. For example, all primaries of the carina (C34.0) have laterality coded '0' and all primaries of the main bronchus have laterality coded '1'-'9'.

ICD-O Code	**Primary Site**
C07.9	Parotid gland
C08.0	Submandibular gland
C08.1	Sublingual gland
C09.0	Tonsillar fossa
C09.1	Tonsillar pillar
C09.8	Overlapping lesion of tonsil
C09.9	Tonsil, NOS
C30.0	Nasal cavity (excluding nasal cartilage, nasal septum)
C30.1	Middle ear
C31.0	Maxillary sinus
C31.2	Frontal sinus
C34.0	Main bronchus (excluding carina)
C34.1-C34.9	Lung
C38.4	Pleura
C40.0	Long bones of upper limb, scapula and associated joints
C40.1	Short bones of upper limb and associated joints
C40.2	Long bones of lower limb and associated joints
C40.3	Short bones of lower limb and associated joints
C41.3	Rib, Clavicle (excluding sternum)

C41.4	Pelvic Bones (excluding sacrum, coccyx, and symphysis pubis)
C44.1	Skin of eyelid
C44.2	Skin of external ear
C44.3	Skin of other and unspecified parts of face (midline code '9')
C44.5	Skin of trunk (midline code '9')
C44.6	Skin of upper limb and shoulder
C44.7	Skin of the lower limb and hip
C47.1	Peripheral nerves and autonomic nervous system of upper limb and shoulder
C47.2	Peripheral nerves and autonomic nervous system of lower limb and hip
C49.1	Connective, subcutaneous, and other soft tissues of upper limb and shoulder
C49.2	Connective, subcutaneous, and other soft tissues of lower limb and hip
C50.0-C50.9	Breast
C56.9	Ovary
C57.0	Fallopian tube
C62.0-C62.9	Testis
C63.0	Epididymis
C63.1	Spermatic cord
C64.9	Kidney, NOS
C65.9	Renal pelvis
C66.9	Ureter
C69.0-C69.9	Eye and adnexa
C70.0	Cerebral meninges, NOS (effective with cases diagnosed 1/1/2004)
C71.0	Cerebrum (Effective with cases diagnosed 1/1/2004)
C71.1	Frontal lobe (Effective with cases diagnosed 1/1/2004)
C71.2	Temporal lobe (Effective with cases diagnosed 1/1/2004)
C71.3	Parietal lobe (Effective with cases diagnosed 1/1/2004)
C71.4	Occipital lobe (Effective with cases diagnosed 1/1/2004)
C72.2	Olfactory nerve (Effective with cases diagnosed 1/1/2004)
C72.3	Optic nerve (Effective with cases diagnosed 1/1/2004)
C72.4	Acoustic nerve (Effective with cases diagnosed 1/1/2004)
C72.5	Cranial nerve, NOS (Effective with cases diagnosed 1/1/2004)
C74.0-C74.9	Adrenal gland
C75.4	Carotid body

Appendix 8 HIQA Correspondence

Appendix 8.1 HIQA Correspondence

Secondary use of data as a method to improve Data Quality in a theatre setting.

Meeting date: 08th May 2014

Information Request

Dear Linda,

I have put together some thoughts on measuring data quality based on my thesis ahead of our meeting on Thursday.

HIQA recommends seven data dimensions which contribute to data. In my thesis I have measured three dimensions namely completeness, concordance between the theatre log book and the electronic system and timeliness.

Q1. Is there a proposed system making it possible to measure all seven data dimensions?

Q2. Has a standard approach to measuring the data quality dimensions been developed?

Q3. Preparing electronic data for secondary purposes is quite a lengthy process, which may deter clinicians. What are your thoughts on this?

I utilised the findings from phase 1 of my study to drive improvement in data quality in phase 2. SWOT analysis was used to provide feedback to key players and KPIs were developed based upon guidance from phase 1 findings. This lead to improvements in data quality, particularly in relation to data completeness.

Q4. What are your ideas around improving data quality from HIQA's perspective?

Q5. Where do you see the role of secondary data and data quality monitoring going within the next three years?

Linda Weir
Health Information Officer

Questions and Answers

Q1. Is there a proposed system making it possible to measure all seven data dimensions?

HIQA undertook an extensive review of International literature before assigning dimensions that constitute data quality dimensions. Seven data quality dimensions were identified.

It was agreed that it is not feasible to measure all seven dimensions at once. A selection process needs to take place identifying the most suitable dimensions for the measurement at hand and a rational for this. Reference was made to the CIHI framework, which provides an assessment tool for the measurement of five data quality dimension; accuracy, timeliness, comparability, usability and relevance. The audit commission has produced comprehensive reports on the generation of "fit-for-purpose information. They have identified descriptors of six quality dimensions.

Q2. Has a standard approach to measuring the data quality dimensions been developed?

The CIHI framework has devised a standardised approach to measuring the aforementioned data quality dimensions. This is based on the concept of identifying the numerator and dominator and expressing this as a percentage, with built-in adjustment for over and under coverage of data. This is similar to how I calculated the scores in my thesis.

Q3. Preparing electronic data for secondary purposes is quite a lengthy process, which may deter clinicians. What are your thoughts on this?

We discussed the lengthy process of obtaining, cleaning, organising the data before undertaking the quality measures. CIHI has developed process that minimise the burden of data capture and collection. It is likely that HIQA's will provide additional guidance for data capture and collection in the future and identify standardised tools.

Q4. What are your ideas around improving data quality from HIQA's perspective?

- Strong and clear leadership, which reinforces the need for high quality data
- Involving users in data quality, determine what information is appropriate to their use and providing feedback from audits/research.
- HIQA monitoring of information standards (Theme 8: Safer Better Care)
- Quality Accounts to monitor standards for all aspects of healthcare including data quality.

Q5. Where do you see the role of secondary data and data quality monitoring going within the next three years?

The following events will change the face of data quality and secondary use of data over the next few years;

- The publication of the Health information Bill will safeguard the interests of patients, health and social care services and HIQA and ensure the best use of health information going forward.
- The unique identifier will promote the quality and safety of patient information and care.
- HIQA's licencing of hospitals and continued growth in their quality assurance functions will provide on-going growth and development of data quality.
- HIQA guidance documents will become national standards following the publication of the Health information Bill.

Appendix 9 Data Commissioner Correspondence

Appendix 9.1 Data Commissioner Correspondence

Appendix Data Commissioner

Secondary use of data in research and consent

Ann Keane <keanea8@tcd.ie> 6 May

For the attention of the Compliance Section

I am currently undertaking a post graduate MSc in Health Informatics at TCD, Dublin. My thesis is an investigation into the use of secondary data as a means of improving data quality in an operating theatre setting. This is an area of great interest to me as a nurse working in the Information technology department at an acute hospital.

In my literature review I have looked extensively at consent in relation to secondary use of data and data protection laws and regulations in force in Ireland. My study method is pre and post test analysis of operating theatre data obtained from an electronic system.

Measures were taken to ensure that patient information was appropriately and respectfully managed and was compliant with ethical considerations, laws and regulations. There was no identifiable data at the time of analysis and reporting. Data was anonymised by removing identifiable information including the patient's name, date of birth, Medical Record Number, surgical procedure the Consultant Surgeon's name, theatre name and hospital location before the analysis stage.

In conjunction with my study, I attended the National Data Protection Conference on the 28th January 2014 and found this day very interesting and informative. With continued progress and evolution in computerised technology, I am aware that the risks of personal data disclosure are increased. Patient consent was not required in my study as anonymity was maintained, nonetheless, this practice may change in the future as Ireland comes in line with data protection standards across the 28 EU member states and Iceland, Norway and Liechtenstein. I would be grateful if you could provide any up-to-date information in relation to research, secondary use of data and consent in healthcare.

Kind Regards

Data Protection 16 May (5 days ago)

Dear Ms Keane,

I refer to your recent email to this Office.

The Data Protection Acts provide an exemption for the processing of personal data for statistical, research or scientific purposes where the processing is carried out by the data controller itself where there are no disclosures of personal data to any outside third parties. Furthermore, the data will not be considered to have been unfairly obtained on account of the fact that the use of the data for research was not disclosed, as long as no damage or distress is likely to be caused to an individual. However, these exemptions can only be claimed by a data controller itself in respect of research carried out by it.

The position in relation to medical research has not changed since January, essentially where patient data is anonymised by the data controller prior to its access by a third party, there is no need from a data protection perspective to seek the consent of patients for the use of the data for research and clinical audit purposes.

I hope this is of some assistance.

Regards

Siobhán Brown
Compliance Officer

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Office of the Data Protection Commissioner
Canal House
Station Road
Portarlington
Co Laois
Ireland
telephone: 057 868 4800
fax: 057 868 4757
website: www.dataprotection.ie

Ann Keane <keanea8@tcd.ie> 20 May (1 day ago)

to Data

Dear Siobhan,
Thank you so much for your reply to my query. Your wording adds great clarity and also offers reassurance for the work I have undertaken.

Kind Regards