

The effect of a prescriber training intervention on the prevalence and types of prescribing errors generated by an electronic prescribing system

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in partial fulfilment of the requirements for the degree of
Master of Science in Health Informatics

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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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Summary

Introduction

Electronic prescribing systems are being increasingly considered and implemented in healthcare settings internationally. These systems aim to improve the safety, quality, and efficiency of the medication use process. The literature available strongly advocates the importance of training during both the initial and ongoing use of electronic prescribing systems. Despite this however, there is a lack of evidence to demonstrate the effect that ongoing training has on the use and impact of these systems. In order to strengthen the case for resources for staff training for an electronic prescribing system, this dissertation aims to look at the effect of a training intervention on the prevalence and types of prescribing errors generated by an electronic prescribing system.

Study Design and Methods

Audit and feedback methodologies were used for this study. Prescription audits were carried out before and after the delivery of a classroom-based training intervention. The audits were used to measure and analyse the effect of the training intervention on prescribing errors generated by the electronic prescribing system in the genito urinary medicine and infectious diseases (GUIDE) outpatient clinic in St. James's Hospital, Dublin. A questionnaire and clinician observations were carried out with prescribers to gain some insight into their training history, their interaction with the electronic prescribing system, and to receive feedback from them. This information was used to inform the training intervention.

Results

During the pre-intervention prescription audit, 265 prescribing episodes were reviewed, and during the post-intervention audit, 268 prescribing episodes were reviewed. Pre-intervention the rate of error was found to be 73.6 errors per 100 patients. Following the training intervention, this error rate reduced to 25 errors per 100 patients. Statistically significantly more medications prescribed during the pre-intervention audit contained one or more errors when compared with the post-intervention audit (28.6% versus 9.2%, $p < 0.05$). The types of prescribing errors found before the training intervention were broadly similar to those found after the training intervention. However, the rate of certain errors was different following the intervention.

Conclusion

The prevalence of prescribing errors was significantly reduced following the delivery of a classroom-based training session. A large proportion of the errors found in both audits were

system-related errors. The study contributes to bridging the gap in the literature that was identified due to a lack of studies giving evidence to support the need for training and education for electronic prescribing. However, certain limitations exist in this study which must be considered when interpreting the results and drawing conclusions. Nonetheless, the study supports the need for ongoing training of prescribers using an electronic prescribing system. It is hoped that the results of this study can be used to strengthen the case for resources for ongoing staff training for users of electronic prescribing systems, and to plan for the delivery of this training.

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Abbreviations

CPOE	Computerised Physician Order Entry
EHR	Electronic Health Record
EPR	Electronic Patient Record
GP	General Practitioner
GUIDE	Genito Urinary Medicine and Infectious Diseases
GUM Specialists	Genito Urinary Medicine Specialists
HIQA	Health Information and Quality Authority (Ireland)
HIV	Human Immunodeficiency Virus
ICIP	IntelliVue Clinical Information Portfolio®
ICU	Intensive Care Unit
IMS	Information Management Services
MESH	Medical Subject Headings
NHS	National Health Service (UK)
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
STI	Sexually Transmitted Infection
UK	United Kingdom
USA	United States of America
WHO	World Health Organisation

Chapter 1. Introduction

“The good news about computers is that they do what you tell them to do. The bad news is that they do what you tell them to do.”

— Ted Nelson (Demakis, 2012)

1.1 Background and Motivation

Electronic prescribing systems are being increasingly considered and implemented in healthcare settings internationally (Cresswell et al., 2013b). These systems aim to improve the safety, quality, and efficiency of the medication use process (Cresswell et al., 2013b). Anticipated benefits of these systems include improved legibility; reduced dosing errors; prevention of duplicate prescribing; decision support; improved communication between healthcare providers; provision of a robust audit trail for the entire medicines use process; and increased efficiency (Cresswell et al., 2013a, Schofield et al., 2015, Redwood et al., 2011). The introduction of such systems requires considerable changes in the way healthcare professionals perform their roles and organise their work (Schofield et al., 2015).

The initial implementation of electronic prescribing systems within a hospital is a major transformational project and can be extremely disruptive (Cresswell et al., 2013a, Australian Commission on Safety and Quality in Health Care, 2012). It is important that these systems are carefully implemented to maximise the likelihood of benefit to patients (Cresswell et al., 2013a). Consideration of the impact of such systems on working practices is crucial for successful implementation (Burgin et al., 2014). If the systems are poorly designed and implemented, and under-resourced, they have the potential to adversely affect safety and quality of care (Australian Commission on Safety and Quality in Health Care, 2012). In their report “Electronic Medication Management Systems — A Guide to Safe Implementation”, the Australian Commission on Safety and Quality in Health Care (2012) outline that insufficient time or resources allocated to training, particularly for medical staff, is a potential risk to the success of electronic prescribing implementation projects. They recommend considering the resource requirements needed for ongoing maintenance of the system prior to its implementation. They recommend the availability of resources for ongoing refresher training, training of new staff, training in new features, and opportunistic training. They advise that due consideration should be given to their recommendations because, despite initial planning, electronic prescribing systems may still be used inconsistently or in unexpected ways following implementation (Crosson et al., 2008). Ongoing training is important to prevent users adopting unsafe system workarounds (Australian Commission on Safety and Quality in Health Care, 2012). Despite the widespread focus in the literature on the need for training during both the

initial and ongoing use of electronic prescribing systems, there is a lack of evidence to demonstrate the effect that ongoing training has on the use and impact of these systems.

In the study setting of St. James's Hospital, electronic prescribing and medication administration is likely to be rolled out throughout the hospital in the next number of years. As highlighted above, the literature suggests that training requirements should be considered prior to the roll out of electronic prescribing. In Irish hospitals, junior intern doctors must complete general surgical and medical rotations of at least three months (Health Service Executive, 2015). This means that potentially there are new prescribers entering the hospital every three months who will require training in the use of an electronic prescribing system. With this comes the need for resources to ensure all prescribers are trained to allow safe and effective prescribing.

In order to strengthen the case for training resources for an electronic prescribing system, this dissertation aims to analyse the effect of a training intervention on the prevalence and types of prescribing errors generated using an electronic prescribing system currently in use. In the Genito Urinary Medicine and Infectious Diseases (GUIDE) outpatient clinic in St James's Hospital, the Cerner® Electronic Patient Record (EPR) is currently in use as a full patient record and ordering system. Patients' medications are prescribed electronically by clinicians in the GUIDE clinic using the EPR. These prescriptions are then dispensed by the GUIDE pharmacy. While all clinicians prescribing in the GUIDE clinic have undergone initial electronic prescribing training, a number of ongoing issues with prescription quality still occur. The study aims to show the effect of ongoing training on prescribing errors made by users who have already received initial training. It is hoped that the training intervention will result in an improved quality of prescriptions and a reduced rate of prescribing errors. Therefore, it is hoped that the results can be used to highlight the importance of ongoing training for users of an electronic prescribing system.

1.2 Research Questions

The research questions to be answered in the dissertation are:

1. *What is the effect of a training intervention on the prevalence of prescribing errors for prescriptions generated by an electronic prescribing system in a genito urinary medicine and infectious diseases outpatient clinic?*
2. *What are the types of prescribing errors occurring for prescriptions generated by an electronic prescribing system in a genito urinary medicine and infectious diseases outpatient clinic before and after a training intervention?*

1.3 Overview of the Research

The study involved a detailed review of the literature to evaluate the research previously undertaken in relation to the topics of this study. The literature review was used to identify gaps in the research, to provide a rationale for this research study, and to guide the development of the research questions. Following this, the research questions, aims and objectives were developed. Primary research took the form of an audit and feedback cycle, to assess the effect of a training intervention on prescribing errors for prescriptions generated by an electronic prescribing system. Data collection forms were developed and piloted. A pre-intervention prescription audit was carried out to measure the baseline performance. After the initial audit, a questionnaire was completed by prescribers to gain insight into their interaction with the electronic prescribing system and to understand their training backgrounds. Two clinicians were observed to help understand how the system is used in practice. The literature, pre-intervention audit, questionnaire and clinician observations were used to inform the design of a training intervention. The training intervention was designed, and subsequently delivered in a classroom session to prescribers. Following the training intervention, a post-intervention prescription audit was carried out. The results of the pre-intervention and post-intervention audits were compared to assess the effect of the training intervention on the prevalence and types of prescribing errors and therefore answer the research questions.

1.4 Overview of the Dissertation

Chapter 1 has introduced the dissertation topic, presented the motivation for the research, outlined the research questions, and introduced the research undertaken.

Chapter 2 presents the findings of the literature review. The review presents information from the literature about medication and prescribing errors, electronic prescribing, and prescribing education and training. The application of the literature review findings to this study are also presented.

Chapter 3 outlines the study design and methodologies. This chapter describes the research questions, aims and objectives, as well as the research approach and methods. Details of the study are discussed including the study duration and setting, sampling methods, and ethical considerations.

Chapter 4 presents the results of the study. Results from the pre-intervention and post-intervention audits are presented and compared. Key findings from the questionnaire and details of the training intervention are also outlined.

Chapter 5 evaluates and analyses the results of the study. The results of the study are discussed in order to answer the research questions and to reflect on the literature review.

Chapter 6 concludes the dissertation. The study results are reflected upon, strengths and limitations of the study are discussed, and areas for future work are identified.

Chapter 2. Literature Review

2.1 Introduction

In preparation for the primary research in this study, a literature review was carried out to evaluate the research previously undertaken in relation to the topics of this study. The literature review was used to identify gaps in the research, to provide a rationale for this research study, and to guide the development of the research questions. In this chapter the results of the literature review are presented.

2.2 Method

A review of the literature was conducted. Various online resources were used. Searches were performed using primary online databases including PubMed, Thomson Reuters Web of Science, SciVerse Scopus, The Cochrane Library, and Google. A number of keywords were searched for including “prescribing errors”, “medication errors”, “prescription errors”, “electronic prescribing”, “prescribing”, “training”, “information technology”, “education”, and “educational interventions”. In most cases the advanced search tool was used and limits were imposed, such as date ranges and English language. For the PubMed database, the Medical Subject Headings (MeSH) search tool was used to assist with searching for particular subjects. The results of the primary database searches are outlined in Table 2.1. The original reports and journal articles cited in many of the published articles were also searched for directly using the primary databases. Information was also obtained from other sources such as the Irish Health Information and Quality Authority (HIQA), the Irish Statute Book, the Irish Data Protection Commissioner’s website, and the Trinity College Dublin Library. The references obtained from the literature review were grouped into categories to facilitate with synthesising the evidence from the literature.

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement was used to evaluate the systematic reviews appraised in this literature review (Moher et al., 2009). The PRISMA statement consists of a checklist and flow diagram, and is primarily intended to support authors when reporting systematic reviews and meta-analysis. While the PRISMA statement can help when critically appraising systematic reviews that have been published, Moher et al. (2009) state that the PRISMA checklist “is not a quality assessment instrument to gauge the quality of a systematic review”. A copy of the PRISMA checklist can be seen in Appendix A. For the purpose of this literature review this checklist was used as a tool to aid the appraisal of published reviews.

Table 2.1: Details of databases and search terms used in the literature review

Database	Search Terms	Limits	Results
PubMed	medication AND errors	Language: English, Dates: Last 10 years, Species: Humans	6,953
PubMed	prescribing AND errors	Language: English, Dates: Last 10 years	1,379
PubMed	prescription AND errors	Language: English, Dates: Last 10 years, Species: Humans	1,591
PubMed	prescribing AND error AND rates	Language: English	155
PubMed	electronic AND prescribing AND systems	Language: English, Dates: Last 10 years	779
PubMed	electronic prescribing [Title]	Language: English	199
PubMed	electronic AND prescribing AND errors	Language: English	473
PubMed	prescribing AND education	Language: English, Dates: Last 10 years, Species: Humans	2,185
PubMed	prescribing AND educational AND interventions	Language: English, Dates: Last 10 years, Species: Humans	173
PubMed	electronic AND prescribing AND education	Language: English, Dates: Last 10 years, Species: Humans	245
PubMed	electronic AND prescribing AND training	Language: English	461
PubMed [MeSH]	("Drug Prescriptions"[Mesh]) AND "Electronic Prescribing"[Mesh]	Language: English	90
PubMed [MeSH]	("Electronic Prescribing"[Mesh]) AND "Medication Errors"[Mesh]	Language: English	182
PubMed [MeSH]	("Drug Prescriptions"[Mesh]) AND "Medication Errors"[Mesh]	Language: English	1,320
PubMed [MeSH]	("Electronic Prescribing"[Mesh]) AND "Education"[Mesh]	Language: English	47
PubMed [MeSH]	("Medical Informatics"[Mesh]) AND "Education"[Mesh]	Language: English, Dates: Last 10 years, Species: Humans	6,952

Database	Search Terms	Limits	Results
Wed of Science	prescri* AND error	Language: English, Dates: 2006-2015	9,020
Wed of Science	prescribing AND training	Language: English, Dates: 2006-2016	10,548
Wed of Science	electronic AND prescribing AND training	Language: English, Dates: 2006-2016	242
Wed of Science	electronic AND prescribing AND education	Language: English, Dates: 2006-2016	372
SciVerse Scopus	electronic AND prescribing AND errors	Language: English	813
SciVerse Scopus	electronic AND prescribing AND training	Language: English	167
SciVerse Scopus	electronic AND prescribing AND education	Language: English	372
Cochrane	electronic prescribing		53
Cochrane	prescribing errors		16
Cochrane	education		7
Cochrane	prescribing training		23
Cochrane	computer training		24
Cochrane	information technology training		9

2.3 Medication Errors

2.3.1 Overview of Medication Errors

In 1999, the Institute of Medicine estimated that between 44,000 and 98,000 people die annually in hospitals in the United States of America (USA) as a result of preventable medical errors (Kohn et al., 1999). In a recent British Medical Journal article, Makary and Daniel (2016) have suggested that medical error is the third leading cause of death in the USA. The Institute of Medicine have defined a medical error as

“...the failure of a planned action to be completed as intended (error of execution) or the use of a wrong plan to achieve an aim (error of planning). An error may be an act of commission or an act of omission” (Wittich et al., 2014).

Medical errors include errors associated with diagnosis, treatment, and preventative therapy (Kohn et al., 1999). Errors can result in reduced satisfaction by both healthcare professionals and patients, and can lead to a loss of trust in health care systems (Kohn et al., 1999). Patients may pay for errors both physically and psychologically, while healthcare professionals may lose morale.

Examples of medical errors outlined by the Institute of Medicine which relate to medication include treatment administration errors, drug dosing errors, errors in the method of using a drug, prophylactic treatment delivery failures, and communication failures (Kohn et al., 1999). Among the most common avoidable causes of unintended adverse events in medication practice are errors in the prescribing, preparation, dispensing, storing, and administration of a medicine (European Medicines Agency, 2015, Commission on Patient Safety and Quality Assurance, 2008). Of all adverse events that occur among patients in hospital, it has been estimated that between 18.7% and 56% result from medication errors that are preventable (European Medicines Agency Pharmacovigilance Risk Assessment Committee, 2015a). Healthcare professionals have a responsibility to ensure that patients are prescribed appropriate medications without errors (European Medicines Agency Pharmacovigilance Risk Assessment Committee, 2015b).

2.3.2 Defining a Prescribing Error

Throughout the literature many definitions have been proposed to define medication errors and prescribing errors (Velo and Minuz, 2009, Avery et al., 2012, Ferner and Aronson, 2006, Dean et al., 2000, Wittich et al., 2014). A systematic review of definitions and characteristics of medication errors, by Lisby et al. (2010), found 26 different wordings for a generic definition of medication errors in 45 studies. In their systematic review of prescribing errors, Ross et al.

(2009) also found substantial differences in definitions of errors which, they report, makes it difficult to reach meaningful conclusions on studies relating to prescribing errors. Additionally, definitions are often ambiguous, or indeed not given, in quantitative studies which can also make interpretation of results difficult (Dean et al., 2000). Instead of being reproducible, it appears that definitions are subject to the preferences of individual researchers (Lisby et al., 2010). Lisby et al. (2010) recommend that the adoption of a well-defined, clear definition, in addition to standardised terminology, has the possibility to greatly improve the consistency and quality of medication error reporting.

Notwithstanding the limitations identified in the previous paragraph, a medication error is generally seen as an error that happens at any point in the process of medication use (Wittich et al., 2014). Prescribing errors can be seen as a subset of medication errors which take place at the point of prescribing, during the decision making process, or in the writing of a prescription (Aronson, 2009). A prescription is a written order that includes detailed instructions of which medication should be given to which patient; in which dose, formulation and route; how frequently; and for what duration (European Medicines Agency Pharmacovigilance Risk Assessment Committee, 2015b).

A definition that has been cited in much of the literature reviewed, is that which was developed by Dean et al. (2000) following a review with a panel of healthcare professionals. Their definition of a prescribing error states that

“a clinically meaningful prescribing error occurs when, as a result of a prescribing decision or prescription writing process, there is an unintentional significant (1) reduction in the probability of treatment being timely and effective, or (2) increase in the risk of harm when compared with generally accepted practice.”

Velo and Minuz (2009) note that the definition by Dean et al. (2000) is concerned mostly with the outcome of the error, and they reflect that it does not consider failures that may occur during the entire prescribing process, independent of any actual or potential harm. Additionally, the Irish National Medicines Information Centre (2001) state that prescribing errors can include failure of prescriptions to comply with legal requirements. For example, in Ireland there are specific legal requirements for the prescribing of medications containing controlled drug substances (Irish Statute Book, 1988).

Accompanying their definition of a prescribing error, specified above, Dean et al. (2000) have listed 27 situations that should be included as prescribing errors; 7 situations that may be considered prescribing errors, depending on the individual clinical situation; and 8 situations that should be excluded as prescribing errors. All of these situations can be seen in the tables

in Appendix B. An overview of the error categories for the 27 situations that Dean et al. (2000) suggest should be included as prescribing errors are listed in Table 2.2

Table 2.2: Error categories for situations that should be included as prescribing errors (as per the Dean et al. (2000) definition of a prescribing error).

Errors in decision making
Prescription inappropriate for the patient concerned
Pharmaceutical issues
Errors in prescription writing
Failure to communicate essential information
Transcription errors

For the purpose of this dissertation, the term prescribing error will be used interchangeably with the term prescription error. This reflects the fact that there is no universal definition of a prescribing error and some studies reviewed refer to the term prescription error, whereas others refer to the term prescribing error in the same context.

2.3.3 Incidences of Prescribing Errors

Prospective and retrospective studies have quantified the prevalence of prescribing errors (Velo and Minuz, 2009). The incidence of observed prescribing errors can vary greatly as a result of wide-ranging criteria used to define and identify errors (Velo and Minuz, 2009). For example, in a systematic literature review on prescribing errors among junior doctors, Ross et al. (2009) found considerable variation in the rate of error reported. The rates ranged from 2 to 514 prescribing errors per 1000 items prescribed, and errors found in charts or patients reviewed ranging from 4.2% to 82% of those reviewed. Ross et al. (2009) suggest that the significant variation in results may be due to the range of study designs, research methods, and definitions of errors reported in the various studies. This review by Ross et al. (2009) is relevant to the dissertation research as it focuses on prescribing errors, and was carried out with the purpose of informing the design of an educational intervention. However, it is noted that this review by Ross et al. (2009) does not mention anything about electronic prescribing or its associated errors. They also focus on junior doctors prescribing, whereas, in this dissertation, research was performed with a group of senior clinicians. A strength of this review by Ross et al. (2009) is that it groups studies by their method of reporting errors. This is helpful in highlighting the different approaches that may be undertaken in studies. Many of the points in the PRISMA statement checklist, outlined in section 2.2 and Appendix A, were not addressed in this systematic review, in particular in relation to the methods section.

Velo and Minuz (2009) report that 70% of medication errors, that have the potential to cause adverse effects, are caused by prescription errors. In addition, they report that over 50% of all prescribing faults are due to errors in dose selection. However, in their review of medication errors the source or context of these prevalence percentages were not given, which makes interpretation difficult.

Avery et al. (2012) reviewed the prevalence of prescribing errors in general practice in the PRACtICE study. The study examined 1,777 patients' records containing 6,048 prescription items. 12.5% of patients had a prescribing or monitoring error; this involved approximately 5% of all the prescription items reviewed. Of the errors found, the majority were classed as mild to moderate in severity, with one in 550 errors being classed as severe. Of note, the errors found in prescribing and monitoring were not associated with whether prescriptions were acute or repeat items, or with the grade of general practitioner (GP) prescribing. A strength of this study is that it included systematic reviews using the Cochrane Effective Practice and Organisation of Care data collection checklist and template. The study is a retrospective review of prescribed medications in a sample of medications from 15 GP practices and included interviews with prescribers. This study is useful to compare to the research in this dissertation as, similar to the study setting in the GUIDE clinic, the PRACtICE study is set in the outpatient setting and all GP practices examined had a computer system in place which was used to generate prescriptions. Unlike many of the studies reviewed, which were assessing prescribing errors by junior doctors, the PRACtICE study assesses GP prescribing. GPs are more experienced than junior doctors and have undergone specialist training, which is possibly more comparable to the senior specialist clinicians who prescribe medications in the GUIDE clinic. However, the range of medications prescribed in general practice is much vaster than in the GUIDE clinic. The study provided useful demographics which were used to compare prescribing errors. This helped to influence the demographic characteristics selected for review in this dissertation study. It is noted that the PRACtICE study used retrospective case note review to capture prescribing errors, while this dissertation study involves real-time prospective collection of data.

Dean et al. (2002b) investigated the incidence of prescribing errors among inpatients in a hospital in the United Kingdom (UK). In their study, pharmacists prospectively recorded details of prescribing errors identified during a 4-week period. A prescribing error was identified in 1.5% of the 36,168 prescriptions, with 0.4% of prescriptions having a potentially serious error. The majority of errors (54%) were associated with dosing choice. Dean et al. (2002b) suggest that pharmacists routinely intercept errors, but they only provide the individual prescriber responsible for the error with the feedback. Although this is helpful and leads to correction in errors, Dean et al. (2002b) highlight that without a regular monitoring and feedback system,

errors are not shared across the team. Therefore, they suggest, hospital-wide and national issues cannot be studied to try to develop error reduction strategies. This study by Dean et al. (2002b) is similar to the dissertation study as it involves prospective recording of errors by pharmacists screening prescriptions. The authors highlight that while prospective recording of errors is a useful way of capturing errors, the main disadvantage is that variations between pharmacist data collectors and under-reporting can occur due to workload pressures. The potential variations between pharmacist data collectors were considered when designing the dissertation study. Unlike the dissertation study, which reviewed prescriptions generated by an electronic prescribing system, the study by Dean et al. (2002b) reviewed inpatient handwritten prescriptions.

2.3.4 Causes of Prescribing Errors

Prescribing is considered to be a complex and high-risk procedure (Velo and Minuz, 2009, Kamarudin et al., 2013). Human error theories suggest that, while errors in prescribing depend on individual failings, they are generated or facilitated by system failures (Velo and Minuz, 2009, Reason, 2000). Reason (2000) developed the “Swiss cheese” model, which outlines that insufficient system defences and sequential system failures are required for an event of accidental causation to occur. Holes in system defences can be caused by active failures and latent conditions (Reason, 2000).

Active failures are the unsafe acts performed by those in direct contact with the system or patient (Reason, 2000). They may occur due to mistakes, lapses, slips, or procedural violations. Latent conditions are “resident pathogens” within the system. Latent conditions occur due to organisational processes and management decisions (Reason, 2000, Dean et al., 2002a). These latent conditions may remain dormant within the system for some time before creating an accident opportunity when they combine with active failures and local triggers, such as environmental, team, individual, or task factors (Dean et al., 2002a, Reason, 2000).

Many causes of prescribing errors have been identified in the literature reviewed. Some underlying factors that may contribute to prescribing errors are outlined in Figure 2.1.

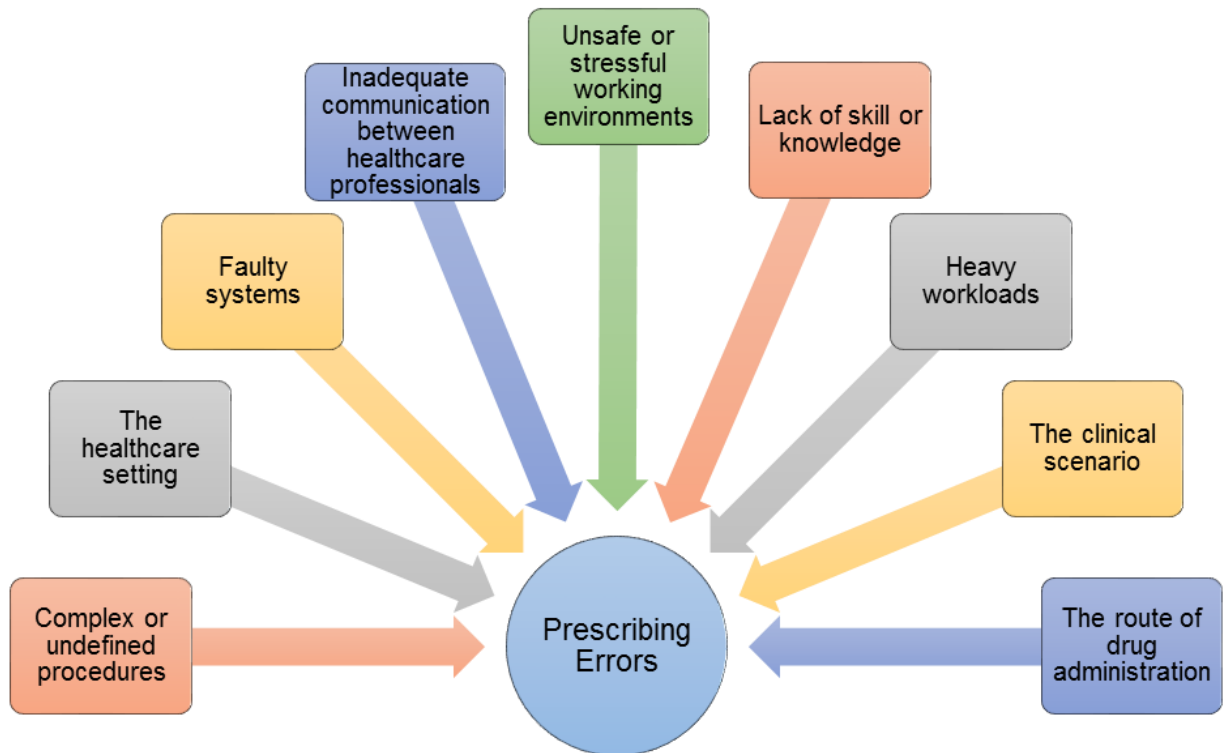


Figure 2.1: Underlying factors that may contribute to prescribing errors (Kohn et al., 1999, Velo and Minuz, 2009, Wittich et al., 2014)

Velo and Minuz (2009) suggest that the more steps in the prescribing process, and larger numbers of prescriptions, may result in a higher risk of error. In order to reduce the risk of medication errors, the European Medicines Agency Pharmacovigilance Risk Assessment Committee (2015a) outline that it is essential to understand the clinical consequences and the contributing factors of an error. They suggest that this is particularly important if an error is occurring continuously or with the same pattern. In doing so, the Committee suggest that mitigating actions and solutions should be understood in order to prevent reoccurrence of the error.

In 2002, Dean et al. investigated the causes of potentially serious prescribing errors which occurred in a study of inpatients in a UK hospital (Dean et al., 2002a). All prescriptions were handwritten. Prescribers who made the errors were interviewed and human error theory was used to analyse the findings. For each error, a main so-called “active failure” was identified. Skill-based slips or lapses were the most common type of active failure contributing to the errors. Such mistakes were commonly caused by a lack of knowledge of a relevant rule, such as dose reduction in particular clinical circumstances. No prescribers were able to explain why these slips and lapses occurred, but 70% of prescribers mentioned they were busy, while 30% mentioned they had been interrupted during a routine task. A key latent condition, highlighted in this study, was that the task of drug prescribing did not seem to be considered important by many doctors. Often junior doctors were told to prescribe a drug, but not given the details of

dose, form, route, frequency, or duration. In this study the authors outline that the act of transcription of prescribed medications was often not seen as prescribing, and was therefore not handled with the same care as prescribing a new drug. The main system defence mechanism identified by those interviewed in the study, was pharmacists identifying and rectifying errors. It was noted that some junior doctors reported relying on pharmacists to perform this role to such an extent that sometimes they would not look up doses. In contrast to this study by Dean et al. (2002a), the dissertation study observed only senior doctors. Interestingly, the current research relies on pharmacists reviewing prescriptions to detect errors prior to dose administration.

2.3.5 Strategies to Reduce Prescribing Errors

As outlined in section 2.3.4, system failures contribute to medication and prescribing errors. The Institute of Medicine suggest, in their landmark report “To Err is Human”, that the best means of preventing medical errors is by designing a safer health system (Kohn et al., 1999). In doing so, systems should be designed to make it easier for people to do the right thing, and harder to do something wrong. While people must be held accountable for their own actions, the Institute advise that blaming individuals for an error does little to prevent reoccurrence of the error and to make the system safer (Kohn et al., 1999).

In order to learn from previous errors, it is important that errors are reported and evaluated in order to put in place preventative and corrective actions (European Medicines Agency Pharmacovigilance Risk Assessment Committee, 2015b). Error-reporting systems have been widely used, usually on a voluntary basis, in order to capture medication errors (Velo and Minuz, 2009). It is recommended that prescribers are informed of errors that have been made in their environment, and of analysis conclusions (Velo and Minuz, 2009).

In addition to system design, active interventions, focused on the education and training of prescribers, are strongly recommended to reduce prescribing errors (Velo and Minuz, 2009, Avery et al., 2012, Wittich et al., 2014). Both system-related error minimisation strategies and prescribers endeavouring to achieve better prescribing are advised to reduce the risk of errors (Velo and Minuz, 2009).

The literature also widely advocates the use of electronic prescribing to reduce prescribing errors (Velo and Minuz, 2009, Avery et al., 2012, Westbrook et al., 2012, Craxford et al., 2015, Donyai et al., 2008, Ammenwerth et al., 2008). Ammenwerth et al. (2008) carried out a systematic review to analyse the relative risk reduction by electronic prescribing on medication errors and adverse drug events. When compared with the PRISMA statement checklist for systematic reviews, outlined in section 2.2 and Appendix A, this systematic review complied with 20 of the 27 checklist items. Areas of non-compliance with the checklist included indication

of existence of a review protocol; presentation of a full electronic search strategy; and specification of assessment of bias. Of the 25 studies analysing the effects of electronic prescribing on medication error rates, 23 demonstrated a significant relative risk reduction of between 13% and 99%. Studies comparing electronic prescribing with handwritten prescribing appeared to show a higher relative risk reduction than those comparing different levels of electronic prescribing and ordering. Furthermore, the addition of advanced decision supports within an electronic prescribing system appeared to demonstrate a higher relative risk reduction, compared to those with no or limited decision support. The authors highlight that the studies in this review differ considerably in their design, setting, quality, and results. They also state that most of the included studies had a poor quality of reporting. The review included both inpatient and outpatient settings; however, sub-group analysis comparing inpatients and outpatients was not performed.

A study in two Australian teaching hospitals, observing rates of prescribing errors before and after the implementation of electronic prescribing, found that the use of an electronic prescribing system resulted in statistically significant reductions in prescribing error rates in all three intervention wards (Westbrook et al., 2012). This was largely due to a reduction in incomplete, unclear and illegal orders. The use of the electronic prescribing system reduced errors from 6.25 to 2.12 per admission in one hospital, and from 3.62 to 1.46 in the other hospital. Similarly, Donyai et al. (2008) compared the rate of prescribing errors before and after the introduction of electronic prescribing in a UK hospital and found a statistically significant reduction in the rate of prescribing errors from 3.8% before, to 2.0% after electronic prescribing implementation. In 1998, Bates et al. found a statistically significant decrease in non-intercepted serious medication errors of 55% (from 10.7 events to 4.86 events per 1000 patient-days), following the introduction of computerised physician order entry, in a large tertiary care hospital in the USA (Bates et al., 1998).

Electronic prescribing can introduce barriers or system defences to errors in the “Swiss Cheese” model of accident causation outlined in section 2.3.4. Functionalities in electronic prescribing systems that may be seen as system defences include drug-allergy alerts, drug-interaction alerts, drug-lab alerts, dosage range checks, drug order sets, and clinical decision support (Ammenwerth et al., 2008). These are defences that are not seen with paper-based systems. Electronic prescribing will be discussed in more detail in section 2.4, including details on errors which can be introduced by electronic prescribing.

2.4 Electronic Prescribing

HIQA describe electronic prescribing as “generally the process of using a computer to generate a prescription” (Health Information and Quality Authority, 2012). Electronic prescribing is not

exclusively about doctors prescribing medication, but is involved in the whole medicines use process (NHS Connecting for Health, 2009). For example, electronic prescribing systems in hospitals are used by nurses, to administer medicines to inpatients, and by pharmacists, to review prescriptions and manage medication supply. For this reason, these systems are often referred to as electronic prescribing and medicines administration systems (NHS Connecting for Health, 2009). For the purpose of this dissertation, these types of systems will continue to be referred to as electronic prescribing systems.

A key aim of electronic prescribing is to generate a complete and legible medication order. Anticipated benefits of electronic prescribing include improved quality, safety and efficacy of medication use; decision support capabilities; improved communication between healthcare professionals; and robust audit trails (Cresswell et al., 2013b, Westbrook et al., 2012, Redwood et al., 2011, Australian Commission on Safety and Quality in Health Care, 2012, NHS Connecting for Health, 2009)

2.4.1 Errors Associated with Electronic Prescribing

While the benefits of electronic prescribing are well documented in the literature, with examples given in section 2.3.5, so too is the ability of electronic prescribing systems to introduce a new source of errors (Westbrook et al., 2013, Cresswell et al., 2013a, Hincapie et al., 2014, Burgin et al., 2014, Redwood et al., 2011, Australian Commission on Safety and Quality in Health Care, 2012, Nanji et al., 2011, Walsh et al., 2006). Errors which may be caused by electronic prescribing systems include timing errors; editing errors; selection errors (particularly relating to dropdown menu selection); duplicate orders; incorrect strength; incorrect directions; incorrect quantity; and omission of information (Westbrook et al., 2013, Hincapie et al., 2014, Nanji et al., 2011, Walsh et al., 2006). While most of these errors are not exclusive to electronic prescribing systems, these errors may be considered “computer-related” or “system-related” errors if it is thought that the main source contributing to these errors is due to the functionality or design of the electronic prescribing system (Walsh et al., 2006, Westbrook et al., 2013). Westbrook et al. (2013) define a system-related error as an error

“...where there was a high probability that the functionality or design of the electronic prescribing system contributed to the error and there was little possibility that another cause, such as lack of knowledge about the drug, produced the error.”

A big concern relating to system-related errors is that they can be frequent in occurrence, but can have a low detection rate (Westbrook et al., 2013). Strategies to reduce system-related errors include minimising free-text prescribing; reducing the number of items in drop-down lists; and building pre-defined and well-designed ‘order sentences’ into the system (Ahmed et al., 2016). Order sentences are defined as “a complete pre-written medication order that includes

dose, dose form (when necessary), route of administration and frequency” (Ahmed et al., 2016). Other risks associated with electronic systems include losing overview of a clinical situation; inferring that entering data results in communication of this data to other members of the healthcare team; cognitive overload; data retrieval errors; and disruptions to workflow patterns (Redwood et al., 2011).

A review by Westbrook et al. (2013) of two electronic prescribing systems found that of the 1,164 prescribing errors identified in 629 admissions, 42.4% of the errors were due to system-related errors. All of the system-related errors were considered to result in clinical errors. Only 13.4% of the system-related errors were detected by ward staff prior to the recorded audit. The most common system-related errors were timing errors (27.4%) and wrong drug strength errors (22.5%).

Shulman et al. (2005) compared the types of errors seen in handwritten prescriptions with those prescriptions generated using computerised physician order entry (CPOE) in an ICU setting. Overall the rate of medication errors was statistically significantly lower with CPOE (4.8% error rate) compared with handwritten prescriptions (6.7% error rate). The proportion and distribution of error types differed in the two groups. The CPOE had a higher proportion of errors related to omission of the required drug (6% of CPOE prescription errors vs 0% of handwritten prescription errors); omission of the prescriber's signature (33.3% of CPOE prescription errors vs 14.1% of handwritten prescription errors); and dosing errors (26.5% of CPOE prescription errors vs 16.9% of handwritten prescription errors). However, it is noted that p values or information regarding statistical significance were not given for these results in this study. While the proportion of certain error types may be greater in the CPOE group, this does not necessarily indicate that the number or rate of these errors was greater. The change in distribution of errors in the CPOE group may be affected by a reduction in the incidence of certain other error types.

2.5 Prescribing Education and Training

In preparation for electronic prescribing implementation, careful design and planning is required to minimise errors and ensure patient safety, and to maximise the benefits of these new systems (Cresswell et al., 2013a, Australian Commission on Safety and Quality in Health Care, 2012). Training and education is a key area, widely advocated throughout the literature, to ensure successful implementation and ongoing use of an electronic prescribing system (Westbrook et al., 2013, Australian Commission on Safety and Quality in Health Care, 2012, NHS Connecting for Health, 2009, Community Pharmacy Cheshire & Wirral, 2014, Craxford et al., 2015). This literature review will now evaluate general prescribing training before focusing on training related to electronic prescribing systems.

2.5.1 General Prescribing Competencies and Training

One of the most common interventions made by doctors to improve their patients' health is the prescribing of medicines (Mucklow et al., 2012, Maxwell and Walley, 2003). Regardless of the speciality chosen, most medical doctors will have to be "specialists" in prescribing medications (Maxwell and Walley, 2003). Interestingly, Maxwell and Walley (2003) highlight that while newly qualified doctors are generally protected from the requirement to perform high-risk practical procedures, they are commonly expected to prescribe powerful drugs from the outset of their careers. The essential skill of prescribing requires health professionals who prescribe to be competent to make decisions to maximise benefits and minimise harm to patients under their care (National Prescribing Service, 2012, Maxwell and Walley, 2003).

Internationally, prescribing competencies have been established to help develop and maintain safe, effective, rational, and responsible prescribers (Kamarudin et al., 2013, National Prescribing Service, 2012, National Prescribing Centre, 2012). Competencies have been described as a combination of skills, knowledge, motives, and behaviours required to effectively perform a function, for example prescribing (National Prescribing Service, 2012, National Prescribing Centre, 2012). In the UK, the National Prescribing Centre (2012) have developed a "Single Competency Framework for All Prescribers", while in Australia, the National Prescribing Service (2012) has developed the "Prescribing Competencies Framework". These competency frameworks can be used to benchmark and inform the design and delivery of educational and training programmes for both new, and experienced prescribers (National Prescribing Service, 2012, National Prescribing Centre, 2012). The core competency areas for each of these frameworks can be seen in Appendix C and Appendix D.

While competency frameworks can help guide education and training programmes, the diverse range of skills needed for good prescribing presents a major challenge to the development of these programmes (Kamarudin et al., 2013). Training is defined as "the action of teaching a person or animal a particular skill or type of behaviour" (Oxford Dictionaries, 2016). This definition refers to a single skill or type of behaviour. As mentioned, this is complicated in the case of prescribing, as there are several skills which need to be taught at once.

Kamarudin et al. (2013) carried out a systematic review of educational interventions aimed at improving prescribing competency. The review concluded that, despite a large body of research aimed at improving prescribing competency through educational interventions, there was a large variety of study designs and outcome measures in the studies reviewed. Kamarudin et al. (2013) state that this variety limits the validity and ability to generalise study conclusions. From their research, Kamarudin et al. (2013) suggest that the World Health Organisation (WHO) "Guide to Good Prescribing" has the most evidence internationally, in a

wide variety of settings, supporting its use to improve prescribing competencies. It is noted that the WHO Guide was written in 1994.

In line with the National Prescribing Centre (2012) and the National Prescribing Service (2012) competencies, outlined in Appendix C and Appendix D, the WHO model outlines a six-step guide to prescribing, including selecting, prescribing, and monitoring an appropriate medicine for individual patients (Kamarudin et al., 2013, deVries et al., 1994). The steps in the WHO model can be seen in Table 2.3.

Table 2.3: The WHO six-step model of prescribing (deVries et al., 1994)

STEP 1	Define the patient's problem
STEP 2	Specify the therapeutic objective
STEP 3	Verify the suitability of your drug
STEP 4	Write a prescription
STEP 5	Give information, instructions and warnings
STEP 6	Monitor (and stop?) the treatment

The WHO “Guide to Good Prescribing” is focused on the practical process of rational prescribing, and gives a number of illustrative examples (deVries et al., 1994). While the Guide is mainly focused on medical students and new prescribers, with the aim of providing good training to prevent the development of poor prescribing habits, it may also be helpful for practicing prescribers (deVries et al., 1994). A controlled study with 219 undergraduate medical students in seven locations was performed to measure the impact of a short training course using the “Guide to Good Prescribing” (deVries et al., 1994). Tests were performed before and after the training intervention. Students in the study group who used the WHO Guide performed statistically significantly better than those in the control group in all patient problems presented.

While the information in this section refers to prescribing competencies and training in the general sense, the next section will review the topic with a focus on training for electronic prescribing systems.

2.5.2 Electronic Prescribing Training

Initial Training

There is an important learning curve when prescribers move from traditional paper-based prescribing to the use of an electronic prescribing system (Craxford et al., 2015). The literature emphasises the importance of training and support during the initial period of use of an

electronic prescribing system (Craxford et al., 2015, Australian Commission on Safety and Quality in Health Care, 2012, NHS Connecting for Health, 2009).

The Australian Commission on Safety and Quality in Health Care (2012) released a comprehensive “Electronic Medication Management Systems: Guide to Safe Implementation”. They recommend that users of an electronic prescribing system must be trained and educated to understand the rationale for their workflow changes. They caution that insufficient time or resources allocated to training poses a potential risk to electronic prescribing projects. The Commission further recommends that an education and training coordinator be part of the electronic prescribing system governance structure, and that “ward-based champions” with additional education and training be made available during implementation. As well as training of regular staff, they highlight the need to identify training strategies for agency and locum staff in large hospital settings.

Ongoing Training

Once an electronic prescribing system is in place, resources are required for training in new features, ongoing refresher training, training of new staff, and opportunistic training (Australian Commission on Safety and Quality in Health Care, 2012, NHS Connecting for Health, 2009). The Australian Commission on Safety and Quality in Health Care (2012) advises that regardless of the quality of initial training, it is unlikely that users will have complete appreciation for the various functions within a system following an initial training session or series of sessions. Thus, they stress the importance of ongoing training and education. Requirements for additional training may be identified through staff feedback sessions or ongoing monitoring of electronic prescribing system data (Australian Commission on Safety and Quality in Health Care, 2012, Abdel-Qader et al., 2010).

Benefits of ongoing training include consolidation of users’ understanding of the overall system functionalities and prevention of users adopting system workarounds which pose a safety risk (Australian Commission on Safety and Quality in Health Care, 2012, NHS Connecting for Health, 2009). Training can also help to build confidence in the system, disclose user concerns, and identify issues with the system (NHS Connecting for Health, 2009). The type and extent of training required is a topic of debate (NHS Connecting for Health, 2009, Ornum, 2009). While some classroom training is seen as useful, others feel that a well-designed system should not require excessive training with users learning more on the job (NHS Connecting for Health, 2009). The training methods used may be different depending on the users being trained (Ornum, 2009). The timing of training is important and should be planned for so that it is not too early (to ensure the information remains current) or too late (NHS Connecting for Health, 2009, Australian Commission on Safety and Quality in Health Care, 2012).

Although the importance of training and education for electronic prescribing is advocated throughout the literature, there are a lack of studies giving evidence to support the effect of training and education on electronic prescribing. For example, in a Cochrane review of interventions for reducing medication errors in children in hospital, no study analysing the effect of training and education for users of an electronic prescribing system was found (Maaskant et al., 2015). Velo and Minuz (2009), in their article on medication errors, outline that large-scale information on the beneficial effects of interventions aimed at reducing prescribing errors (including interventions aimed at improving training and knowledge) is not yet available and is needed. It is noted that a Cochrane systematic review is currently underway to review interventions for reducing medication errors in hospitalised adults (Lopez AS, 2012). Interventions to be included in this review include electronic prescribing, and may support further evidence for the role of electronic prescribing in relation to medication safety. Furthermore, there was a lack of information found in the literature giving specific details relating to different training methods for ongoing use of an electronic prescribing system.

Costs and Resources Associated with Electronic Prescribing Training

The cost of the training required for the implementation and upkeep of a new system must be taken into account when deciding to implement an electronic prescribing system (Porterfield et al., 2014). In addition to the staff members and resources required to ensure the ongoing maintenance of the system itself, the Australian Commission on Safety and Quality in Health Care (2012) recommend that hospitals consider having two full-time trainers after implementing electronic prescribing for ongoing refresher training, training in new features, opportunistic training, and training of new staff. When interpreting this staffing number, it is noted that the hospital size or number of staff using the system is not provided for reference. They also advise that all staffing resources should be appropriately costed, for the required duration, when planning for implementation of electronic prescribing. Given the significant resources and time required for training, the Commission have made recommendations that should be considered when planning for training; these are outlined in Table 2.4.

Table 2.4: Australian Commission on Safety and Quality in Health Care (2012) recommendations for consideration when planning for electronic prescribing training

Schedule broad education sessions before electronic prescribing system–specific training, including basic computer competencies training.
Ensure training materials are available to support the training sessions, including any materials that the vendor supplies and possibly modify these materials to reflect local requirements.
Provide and book training facilities, particularly where the training rooms are a shared resource that needs to be booked in advance.
Time the training to occur close to the go-live date to ensure the information remains current.
Tailor training to different roles and consider the differences in time required to train different stakeholder groups.
Adapt the skills and experience of the trainers, including using generic trainers alongside domain experts (pharmacists providing training to pharmacists, nurses providing training to nurses and midwives, etc.). Pharmacists may also be considered for providing training to medical staff because of their medication domain knowledge.
Provide flexible one-on-one training for medical specialists, including sessions at the start and the end of the day.
Make use of expert electronic prescribing system users and clinical champions to support initial implementations within ward areas and provide additional training to this group.
Engage with medical staffing and medical education to determine how best to train the large number of junior medical staff in public hospitals; the opportunistic use of prescheduled induction education sessions and grand rounds provide a good forum for pre-training education and awareness sessions (these sessions are often well attended and lunch is sometimes provided).
Options for training night duty staff, including night-time training sessions, rostering daytime training, and any specific costs associated with providing this training.
Options for training private specialists, including in their consulting rooms.
Options for training agency staff, including contractual arrangements where agencies train their own staff in accordance with the hospital’s defined requirements.
Provide a drop-in or information room.

Limited information on actual costs of training for electronic prescribing systems was found in the literature. Nanji et al. (2011) recommend that training during the implementation of an electronic health record (EHR) should normally account for 30% to 40% of the costs, however they highlight that it is often left with much less attention. In 2007 a USA psychiatry practice, consisting of ten full-time psychiatrists, reviewed the costs associated with implementing an electronic prescribing system (Health Resources and Services Administration, no date). The total cost of implementation was \$42,332, with annual costs after implementation for ongoing user fees and technical support of \$14,725. These ongoing user fees and technical support costs therefore accounted for a large proportion of the overall costs. Further details on the training costings in this case study were not provided which makes it difficult to assess the context of such costs.

In 2008 the USA eHealth Initiative Foundation produced “A Clinician’s Guide to Electronic Prescribing.” In this Guide they outline that a stand-alone electronic prescribing system is anticipated to cost less than a full EHR incorporating electronic prescribing. The eHealth Initiative Foundation (2008) anticipated, in 2008, that annual costs for stand-alone systems can range from free to approximately \$2,500 per prescriber. Office-based EHRs, according to the Foundations Guide in 2008, are anticipated to cost approximately \$25,000 to \$45,000 per physician to implement. The costs to operate and maintain the EHR are anticipated to be between \$3,000 to \$9,000 per physician per year. These annual costs include technical support, software licensing fees, and updating and replacing used equipment. Once again the costs specifically related to training were not discussed in detail.

2.5.3 General e-Health System Training

In 2012 the WHO published a systematic review which explored the factors that promote or inhibit the implementation of e-health systems (Mair et al., 2012). The review analysed articles from 1995 to 2009. Thirty-seven reviews of e-health implementation met the inclusion criteria. Mair et al. (2012) explain that the methodological quality of the articles meeting their inclusion criteria was poor. In total 801 attributive statements regarding barriers or facilitators to e-health implementation were found. Only 10% of the statements were focused on roles, responsibilities, and training or support issues. Of these 10%, the need to sufficiently train staff members for engagement during implementation was the main focus. Division of labour and the effects on workload were also concerns raised. The authors highlight that these issues were often not discussed in depth, and did not examine the types of ongoing support or training that would be needed. Since this review was carried out for a period up to 2009, and technology is evolving rapidly with new e-health solutions constantly changing, Ross et al. (2015) are now

undertaking an update of this review, focusing on studies published between 2009 and 2014. It is hoped that further information relating to training will be established as part of this review.

2.5.4 Current Electronic Prescribing Training in the Study Setting

In the GUIDE clinic in St James's Hospital there are currently twenty-two doctors and five nurses who prescribe medications electronically (Courtney G, 2015, personal communication). Initial EPR training is provided by the hospital's Information Management Services (IMS) department. This training involves an interactive, classroom-based education session to provide guidance on the use of the entire EPR system to GUIDE clinicians. During this training session examples of the interactions clinicians make with the EPR are worked through. Clinicians are also provided with training manuals for each aspect of the EPR. GUIDE clinicians are then provided with additional classroom-based training, specifically for electronic prescribing, by the lead clinician for the GUIDE EPR. In addition to the classroom training, clinicians are offered one-to-one initial training for electronic prescribing.

Ongoing training is provided annually, in two teaching sessions, by the lead clinician for the GUIDE EPR. This is classroom-based, and the content is influenced by feedback from users on problems they have encountered. Periodic audits of the system and problems which arise also provide information to guide the ongoing training sessions.

2.6 Summary and Application of the Literature Review to this Study

The literature review served to inform the design of the primary research. In addition, it can be used to draw comparisons with the findings of the research. This section summarises the key findings from the literature review and highlights their relevance to this study.

The review has given an overview of medication and prescribing errors, and presented information from the literature regarding definitions for these errors. This information was used to determine what was considered to be a prescribing error in this study.

The incidences and causes of prescribing errors, including errors associated with electronic prescribing, were explored. This information can be used to compare rates of error in this study. It was highlighted in the review that prospective recording of errors by pharmacists screening prescriptions is a useful way of capturing errors. However, this can result in variations between pharmacist data collectors and can also result in under-reporting due to workload pressures (Dean et al., 2002b). This was considered and factored into the design of data collection sheets and the training of data collectors in this study.

Strategies to reduce prescribing errors were presented. The education and training of prescribers was strongly advocated as a recommended strategy to reduce prescribing errors

(Velo and Minuz, 2009, Avery et al., 2012, Wittich et al., 2014). This justifies the choice of a training intervention as the main approach being investigated in this study to reduce prescribing errors. Prescribing education and training were reviewed in more detail for both general prescribing and specifically for electronic prescribing. Specific to electronic prescribing, a key area widely advocated throughout the literature to ensure successful implementation and ongoing use of an electronic prescribing system, is training and education (Westbrook et al., 2013, Australian Commission on Safety and Quality in Health Care, 2012, NHS Connecting for Health, 2009, Community Pharmacy Cheshire & Wirral, 2014, Craxford et al., 2015). This gives further motivation to the choice of intervention strategy for this study.

The importance of reporting and evaluating errors, in order to learn from previous errors and to put in place preventative and corrective actions, was highlighted (European Medicines Agency Pharmacovigilance Risk Assessment Committee, 2015b). Similarly, in order to reduce the risk of prescribing errors, it was outlined that it is essential to understand the clinical consequences and contributing factors of an error, particularly if it is occurring continuously, or with the same pattern (European Medicines Agency Pharmacovigilance Risk Assessment Committee, 2015a). A pre-intervention audit was used to gather error information, which could then be evaluated in line with this strategy. Another error reduction strategy relevant to this study is informing prescribers of errors that have been made in their environment and of analysis conclusions (Velo and Minuz, 2009). This approach was taken as part of the training intervention.

Regarding approaches to training, staff feedback sessions and ongoing monitoring of electronic prescribing system data were highlighted as ways to identify requirements for additional training (Australian Commission on Safety and Quality in Health Care, 2012, Abdel-Qader et al., 2010). This approach was used in this dissertation study in the form of the pre-intervention audit and questionnaire. It was outlined that training can also help to build confidence in an electronic prescribing system, disclose user concerns, and identify issues with the system (NHS Connecting for Health, 2009). The questionnaire offered users an opportunity to disclose concerns and identify issues with the system.

As the type and extent of training required is a topic of debate, it was not clear which strategy was best to employ for this study (NHS Connecting for Health, 2009, Ornum, 2009). The UK National Health Service (NHS) Connecting for Health (2009) stated some classroom training is seen as useful. Given that classroom training is advocated in the literature, and that it was the most practical and time effective approach for the study researcher, this method was used for this dissertation study.

The costs and resources associated with electronic prescribing training were reviewed. Anticipating resource requirements was highlighted as an important part of planning for the implementation of electronic prescribing. A key motivation for this research study was to strengthen the case for resources for staff training for an electronic prescribing system. It is hoped that the case for resources based on the findings of this study can be supported by coupling it with the literature reviewed which advocates for resource allocation.

2.7 Conclusion

The literature review has provided details on various topics related to this study. The literature serves to inform the primary research, and to justify the need for this study. Enabled with the information from the literature review, the next chapter shall outline the details of the study design and methodology adopted for this study.

Chapter 3. Study Design and Methodology

3.1 Introduction

Chapter 2 has presented and reviewed the available literature in relation to the topics of this study. Equipped with this information, the study was designed. This section outlines the research questions, rationale, study design, and methodologies used for this piece of research.

3.2 Statement of the Problem

As outlined in section 2.5.2, there are a lack of studies in the literature that give evidence to support the need for training and education for electronic prescribing. While training and education are well advocated for, evidence for the effect of training and education on users of electronic prescribing systems is lacking. No studies were found during the literature review to show the effect of training or education on prescribing errors in an electronic prescribing system. In order to bridge this gap in the literature, this study will attempt to show what effect ongoing training has on prescribing errors within an electronic prescribing system.

3.3 Research Aim

The aim of the study is to assess the effect of a training intervention on the prevalence and types of prescribing errors for prescriptions generated by an electronic prescribing system in a genito urinary medicine and infectious diseases outpatient clinic.

3.4 Research Objectives

- To review the relevant literature and identify the available evidence regarding general prescribing errors and electronic prescribing errors.
- To review the relevant literature and identify the available evidence regarding electronic prescribing training.
- To assess and analyse the types of prescribing errors happening in the study setting and the prevalence of these errors before a training intervention.
- To survey prescribers to identify their training history and gain insight into their interaction with the electronic prescribing system.
- To design and deliver a training intervention for prescribers with the aim of reducing prescribing errors.
- To assess and analyse the types of prescribing errors happening in the study setting and the prevalence of these errors after a training intervention.

- To compare the prevalence and types of prescribing errors before and after the training intervention and assess the effect of the training intervention.

3.5 Research Questions

The primary research questions are:

1. *What is the effect of a training intervention on the prevalence of prescribing errors for prescriptions generated by an electronic prescribing system in a genito urinary medicine and infectious diseases outpatient clinic?*
2. *What are the types of prescribing errors occurring for prescriptions generated by an electronic prescribing system in a genito urinary medicine and infectious diseases outpatient clinic before and after a training intervention?*

3.5.1 Defining the Questions

In order to answer the questions, and ensure the validity and reproducibility of the study, it is important to outline what a prescribing error will be interpreted as for this study. Based on the literature reviewed in section 2.3.2, it is evident that there is no universal definition of a prescribing error. The definition by Dean et al. (2000), outlined in section 2.3.2, is widely accepted in the literature and shall be adopted as part of the description of prescribing errors in this research. This definition of a prescribing error states that

“a clinically meaningful prescribing error occurs when, as a result of a prescribing decision or prescription writing process, there is an unintentional significant (1) reduction in the probability of treatment being timely and effective, or (2) increase in the risk of harm when compared with generally accepted practice.”

While this definition includes the phrase “clinically meaningful”, it is beyond the scope of this particular study to assign the clinical significance to particular errors or to analyse the level of impact of errors on the patient. Therefore, all errors found will be reported on in this study. The Dean et al. (2000) definition is applicable to both handwritten and electronic prescriptions. While the clinical errors accounted for by this definition may occur in electronic prescribing systems, the definition does not consider that certain errors, as outlined in section 2.4.1, may be introduced as a result of using the electronic prescribing system itself. These system-related errors are defined by Westbrook et al. (2013) as

“...errors where there was a high probability that the functionality or design of the electronic prescribing system contributed to the error and there was little possibility that another cause, such as lack of knowledge about the drug, produced the error.”

In summary, the same error may occur in both a handwritten or electronic prescription, but the source or reason for the error may be system-related in the case of an electronic prescription. Additionally, the electronic prescribing system may introduce new errors that were not seen in handwritten prescriptions.

As highlighted in section 2.3.2, legal errors can also contribute to prescribing errors. In Ireland prescription legislation is primarily outlined in the Irish Statutes S.I. No. 540/2003 - Medicinal Products (Prescription and Control of Supply) Regulations 2003 and S.I. No. 328/1988 - Misuse of Drugs Regulations, 1988, and their subsequent amendments.

For the purpose of this study, prescribing errors will be considered as those covered by the Dean et al. (2000) definition of prescribing errors, without assessment of the clinical meaningfulness of the errors, the Westbrook et al. (2013) definition of system-related errors, and any legal errors. By combining these two definitions and the legislative aspects of prescribing, it is hoped that both traditional clinical prescribing errors and those relating specifically to electronic prescribing are captured.

3.6 Research Approach and Design

3.6.1 Audit and Feedback

The research approach taken was based on audit and feedback methodologies. Audit in the health care setting is usually referred to as “clinical audit”. The UK National Institute for Clinical Excellence (2002) defines clinical audit as

“...a quality improvement process that seeks to improve patient care and outcomes through systematic review of care against explicit criteria and the implementation of change. Aspects of the structure, processes, and outcomes of care are selected and systematically evaluated against explicit criteria. Where indicated, changes are implemented at an individual, team, or service level and further monitoring is used to confirm improvement in healthcare delivery.”

The Irish Commission on Patient Safety and Quality Assurance (2008) states that clinical audit

“...constitutes the single most important method that any healthcare organisation can use to understand and assure the quality of the service that it provides”.

Clinical audit can be used to learn if there are opportunities for improvement in the service provided (Quality & Patient Safety Directorate 2013). The 2012 HIQA National Standards for Safer Better Healthcare, along with professional regulatory bodies such as the Nursing and Midwifery Board of Ireland (formerly An Bord Altranais) and the Medical Council of Ireland,

endorse audit as a means for monitoring, evaluating and improving performance in health care. (Quality & Patient Safety Directorate 2013).

Clinical audit is a cyclical process which is generally outlined in five stages, as illustrated in Figure 3.1 (Benjamin, 2008, National Institute for Clinical Excellence, 2002, Quality & Patient Safety Directorate 2013).

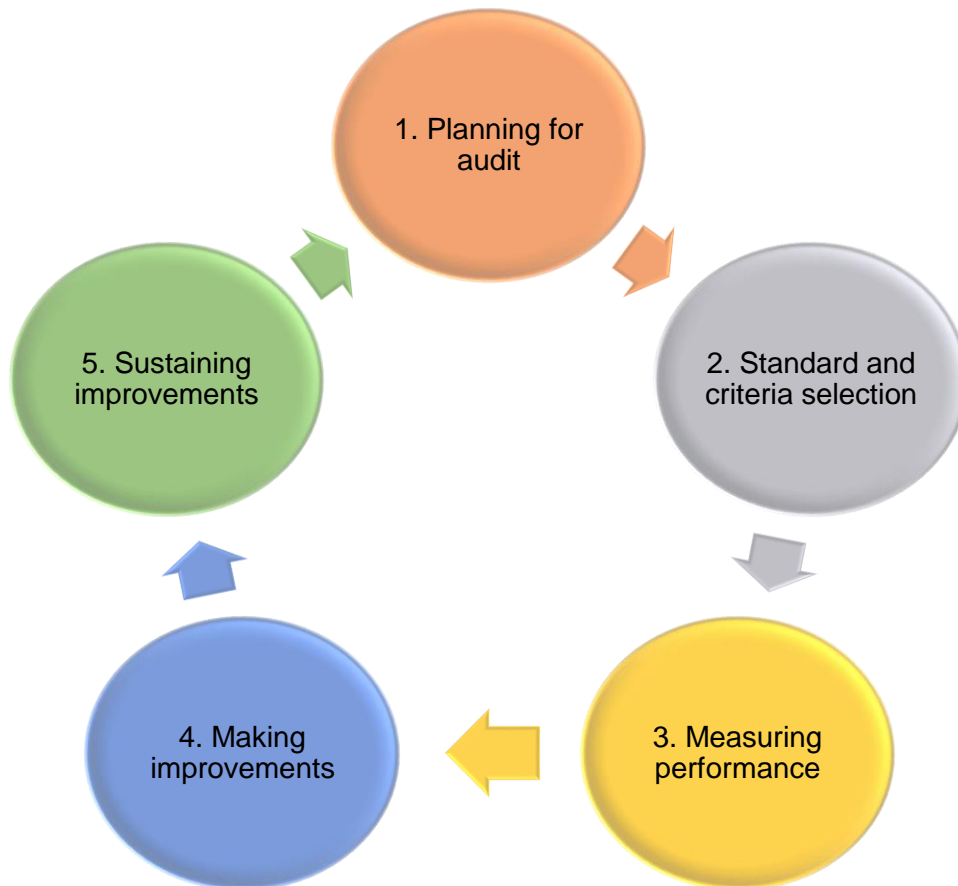


Figure 3.1: Five stages of clinical audit (Benjamin, 2008, National Institute for Clinical Excellence, 2002, Quality & Patient Safety Directorate 2013)

3.6.2 Stages of the Clinical Audit Cycle and their Application to this Research

Stage One - Planning for Audit

Stage one in the audit cycle is planning for audit. This involves identifying problems, areas for improvement, or areas of excellence (Benjamin, 2008, Quality & Patient Safety Directorate 2013). Good preparation and planning is seen as a crucial step to ensure the success of an audit project (National Institute for Clinical Excellence, 2002, Quality & Patient Safety Directorate 2013). This stage consists of a combination of involving stakeholders, determining the audit topic, and planning the delivery of audit fieldwork.

For this particular research, stakeholders recruited into the planning stage included the lead clinician for the EPR in the GUIDE clinic, the chief pharmacist for the GUIDE pharmacy, and the pharmacists working in the GUIDE pharmacy. Input was also obtained from these stakeholders at all stages of the audit.

The topic was chosen since electronic prescribing is topical in St. James's Hospital at present and likely to be rolled out throughout the main hospital in the coming years. Given that the electronic prescribing system proposed to be commissioned in the main hospital is currently in use in the GUIDE clinic, the opportunity to evaluate this system and the effect of training for users of this system was identified. Anecdotally, it was reported by stakeholders that there were issues relating to the quality of prescriptions generated by the electronic prescribing system in the GUIDE clinic. However, prior to the dissertation there has been no systematic evaluation of the types of prescribing errors specifically occurring in the GUIDE clinic or the quality of the prescriptions being generated.

The planned delivery of audit fieldwork involved planning for an initial audit measuring prescribing errors generated by the electronic prescribing system. In order to feedback and improve the quality of prescriptions generated, a training intervention was designed to make improvements to the initial performance. A re-audit was planned to take place after the training intervention to measure the effects of the intervention.

Stage Two - Standard and Criteria Selection

Stage two is standard and criteria selection. This involves reviewing the available evidence and gold standards and determining what you are trying to measure (Benjamin, 2008, National Institute for Clinical Excellence, 2002, Quality & Patient Safety Directorate 2013). In some cases, a standard may be the target for expected compliance or performance level, while for others it may be a statement of best practice (Quality & Patient Safety Directorate 2013).

For this research, the prescriptions were compared to the legal standards for particulars required to be supplied on an outpatient prescription for it to be valid for dispensing; the licensed and clinically accepted dosing standards; and the requirements for prescriptions within the electronic prescribing system. Prescriptions which did not meet these standards were considered to contain an error.

Stage Three - Measuring Performance

Stage three involves measuring performance. Steps included in this stage are data collection and analysis, drawing conclusions, and presenting results.

The details of the data collection and analysis used for this research are outlined in section 3.8. Following the initial audit, which reviewed the prevalence of prescribing errors, the key results were presented to the key stakeholders, including the clinicians using the system. Results were presented and discussed at a training intervention session and disseminated via email.

Stage Four - Making Improvements

Stage four is making improvements. This stage involves reviewing audit findings to identify priority areas where action is required to improve the outcomes (Quality & Patient Safety Directorate 2013). Benjamin (2008) states that without following up and implementing changes, the data collection has no chance of making any impact. Identifying potential barriers to change can help with developing implementation plans (National Institute for Clinical Excellence, 2002). The Irish Health Service Executive Quality & Patient Safety Directorate (2013) recommend that audit results should be used together with feedback and local agreements to improve standards and change clinical practice. However, the UK National Institute for Clinical Excellence (2002) advise that relying on feedback alone should be avoided as the method of realising change. They outline that there is an increased likelihood of change if feedback forms part of a more complex set of change interventions or processes, and that multifaceted interventions tailored for the particular circumstances are more likely to change performance than a single intervention alone. One type of intervention suggested is interactive educational interventions. The UK National Institute for Clinical Excellence (2002) state that these interventions can sometimes, but not always, be effective. They do advise, however, that educational outreach can be a particularly promising approach for implementing change in relation to prescribing behaviour. Educational outreach is a face-to-face session delivered by a trained person to healthcare providers in their own setting (Thomson O'Brien et al., 2000, National Institute for Clinical Excellence, 2002).

Results from this dissertation research were analysed and combined with the information and feedback received from a prescriber questionnaire. In this way, insight was gained into why particular errors may be happening. From this, a prescriber training intervention tailored to the users of the electronic prescribing system in the GUIDE clinic was designed. As guided by the National Institute for Clinical Excellence (2002) recommendations, an interactive training approach delivered in the clinicians own setting was undertaken to try to maximise the intervention's effectiveness. As well as feeding back results of the audit, demonstrations were given during the training intervention to show why particular errors may be happening, and to suggest how they may be avoided. In addition, training was given on the aspects of the system that users reported being unfamiliar with.

Stage Five - Sustaining Improvements

Stage five is sustaining improvements. Any improvement plan implemented as part of an audit should be monitored and assessed; evaluated; sustained; and actions taken to reinforce if necessary (National Institute for Clinical Excellence, 2002, Quality & Patient Safety Directorate 2013). A complete audit cycle involves re-auditing to compare two or more data collections with each other (Quality & Patient Safety Directorate 2013). Further audit cycles may be necessary if desired performance levels are not reached. It is recommended that the results of the re-audit are communicated to all stakeholders.

In this study a second data collection period was held after the delivery of the training intervention. This acted as a re-audit and the results were compared to the initial audit to measure the impact of the intervention on the prevalence of prescribing errors, and to compare the types of prescribing errors occurring before and after the intervention.

Further details on the research methods used in this study can be found in section 3.8.

3.6.3 Evidence for Audit and Feedback

Audit and feedback is a widely used quality improvement strategy (Ivers et al., 2012). This may be influenced by the belief that healthcare professionals are encouraged to change their practice when provided with feedback on their performance if it does not reach the desired target (Ivers et al., 2012). While audit and feedback may improve professional practice, it has been reported that the effects are generally small to moderate (Flottorp et al., 2010). A report by the WHO suggest that audit and feedback benefits are most likely to transpire where current practice is furthest away from the desired target, and when there is more intensive feedback (Flottorp et al., 2010).

In 2012 a Cochrane systematic review was completed to analyse the effectiveness of audit and feedback and to examine factors that may explain variations in the effectiveness (Ivers et al., 2012). This Cochrane review analysed randomised trials of audit and feedback that reported objectively measured patient outcomes or health professional practice. The review found that generally audit and feedback results in small, but potentially important, improvements in professional practice. In keeping with the WHO report mentioned in the previous paragraph, the effectiveness of audit and feedback seems to depend on baseline performance and how the feedback is provided. The Cochrane review found variations in the effectiveness of feedback interventions. Possible explanations given for this include the source, format and frequency of feedback; the baseline performance; the instructions for improvement; and the risk of bias. Multivariable meta-regression showed that when baseline performance or compliance with the desired target or standard is low, feedback may be more

effective. In addition, it may be more effective when the feedback is delivered in both written and verbal formats, and provided more than once. Reynolds et al. (2016) recently undertook research to improve feedback on junior doctors' prescribing errors. In this study, principles of effective feedback were outlined, as shown in Table 3.1.

Table 3.1: Principles of effective feedback according to Reynolds et al. (2016)

Feedback should be as soon as possible after the event.
Feedback should ensure the prescriber is aware that an error has been made.
Feedback should discuss possible solutions.
Feedback should highlight any relevant prescribing resources (for example clinical guidelines).
Feedback should be non-judgemental and blame-free.

In the 2012 Cochrane review, twenty-six trials specifically targeting prescribing behaviour with an unclear or low risk of bias were found (Ivers et al., 2012). The effect of audit and feedback on prescribing habits was relatively large, with a median adjusted risk difference of 13.1%. When the primary author of this study was contacted, he outlined that the 13.1% risk difference “may be thought of as the proportion of patients getting the desired treatment in accordance with guidelines” (Ivers N, 2016, personal communication). The author stated this “could entail prescribing a given drug more or prescribing a given drug less, depending on the trial”. With these results, Ivers et al. (2012) suggest that audit and feedback methods may be highly effective for improving prescribing.

Despite the large number of trials available which review audit and feedback research methods, both the WHO report and the Cochrane review advise that there is uncertainty regarding the best way to introduce audit and feedback into routine practice and regarding the characteristics that lead to a greater impact (Ivers et al., 2012, Flottorp et al., 2010). While the evidence may show limitations to the effectiveness of audit and feedback, given its reported success in prescribing behaviour, and the ability to also contribute to baseline metrics in the GUIDE clinic, this method was chosen for this research. In addition, it was anticipated from stakeholders' feedback that certain errors were occurring at a high frequency. Therefore, in line with the WHO report and Cochrane review, it was predicted that baseline performance or compliance with the desired target or standard may be low for these error types, and so audit and feedback may be relatively more effective.

3.7 Research Setting

The research setting was the GUIDE outpatient clinic in St. James's Hospital. St James's Hospital is a large teaching hospital based in Dublin, Ireland. The GUIDE clinic provides a

genito urinary medicine and infectious diseases service. The GUIDE clinic is the largest sexually transmitted infection (STI), human immunodeficiency virus (HIV) and infectious diseases (including viral hepatitis) service in Ireland (GUIDE Clinic, 2016). The GUIDE outpatient clinic operates in a paperless environment, and all patient scheduling, correspondences, medical notes, ordering and prescribing are performed using the Cerner® EPR. The EPR has been used to prescribe medications electronically in the GUIDE outpatient clinic for approximately four and a half years (Kelly S, 2016, personal communication). Outpatient clinics held here include STI clinics, HIV clinics, viral hepatitis clinics and infectious disease clinics. In these clinics both new and returning patients are reviewed by clinicians.

Patients attending the GUIDE outpatient clinic are frequently prescribed medicines as part of their care. Medications for the treatment of STIs, HIV, viral hepatitis and some other infectious diseases are dispensed to patients attending the clinic by the GUIDE pharmacy, located in the GUIDE clinic. Some of these medications (for example the medications for the treatment of HIV) are unavailable in community pharmacies in Ireland and therefore have to be supplied in the hospital setting (Kelly S, 2016, personal communication). Other medicines, although available in community pharmacies, are supplied free of charge to patients by the GUIDE pharmacy, to facilitate compliance with treatment.

Prescribing clinicians include consultants, genito-urinary medicine (GUM) specialists, registrars, GP trainees, and nurse prescribers. Medications are prescribed electronically by clinicians using the Cerner® EPR. The GUIDE pharmacy receives the electronic prescription via the EPR, and reviews and dispenses the medications accordingly. Only medications administered by the oral and topical route are dispensed by the GUIDE pharmacy; therefore, these were the only medications included in this study.

3.8 Research Methods

3.8.1 Analysing Prescribing Errors

Prior to the collection of the primary error data for this research study, the GUIDE pharmacy staff assessed the types of prescribing errors and issues which were found during the routine dispensing of medications. This information was used to inform the types of errors to be looked for during data collection. Following this assessment, the types of errors and issues found were reviewed and split into five categories as seen in Table 3.2.

Table 3.2: List of potential error types

1.	Error in prescription field
1a	Incorrect drug
1b	Incorrect dose (including incorrect strength/volume OR incorrect unit)
1c	Incorrect form
1d	Incorrect route
1e	Incorrect frequency/administration details – includes “as directed”/ “as required”
2.	Error associated with copying/repeating prescription
2a	Previous prescription copied/repeated but “dispensed status” not amended. The copied/repeated prescription indicates that the prescription is “dispensed”.*
2b	Details in “order comments” or “special instructions” field copied/repeated from previous prescription that are no longer valid/appropriate (other than “dispensed status”).
3.	Error in receipt of task by GUIDE pharmacy
3a	Patient waiting for medications but no order received by GUIDE pharmacy due to omission of prescription.
3b	Patient waiting for medications but no order received by GUIDE pharmacy due to omission of task creation (for example medication was prescribed as part of the incorrect episode).
3c	GUIDE pharmacy task generated but no note and no prescription attached.
4.	Error relating to pre-pack** medicines
4a	Pre-pack** prescription selected but the prescription is intended to be dispensed in the GUIDE pharmacy.
4b	Task received in the GUIDE pharmacy to dispense prescription but the prescription was already dispensed as a pre-pack** by the prescriber.
5.	Clinical error
5a	Inappropriate prescription due to drug-drug interaction
5b	Inappropriate prescription due to patient’s allergy status
5c	Inappropriate dose due to patient’s renal function
5d	Inappropriate prescription for other clinical reason

*The “dispensed status” field indicates whether a prescription is dispensed, partially dispensed or not dispensed. When dispensed prescriptions are copied/repeated, the prescriber must actively remove the selection of “dispensed” from the “dispensed status” field.

**Pre-pack prescriptions are prescriptions for those medications which may be prescribed and dispensed to GUIDE patients by the prescriber. They include single doses of certain once off prescriptions and commonly prescribed short courses of treatment. Pre-pack prescriptions are not dispensed by the GUIDE pharmacy.

The first (errors in prescription fields) and fifth (clinical errors) error categories in Table 3.2 are errors which could occur for both handwritten and electronic prescriptions. These may be seen as the traditional type of prescribing errors covered by the definition by Dean et al. (2000) in section 3.5.1. Although the error types in category one (errors in prescription fields) fall under the Dean et al. (2000) definition, they may also be caused by “the functionality or design” of the electronic prescribing system, as per the Westbrook et al. (2013) definition of system-related errors. For example, the wrong drug, dose, route, or form could be unintentionally selected due to an error in dropdown menu selection.

The second (errors associated with copying prescriptions), third (errors in receipt of task by pharmacy) and fourth (errors relating to pre-pack medicines) error categories in Table 3.2 are system-related errors. More specifically, these errors are system-related errors associated with the particular electronic prescribing system in place in the GUIDE pharmacy. This is because these errors are related to “the functionality or design” of the system.

Error type 2a (“dispensed” status repeated from previous prescription not removed) from Table 3.2 is an example of a legal error. According to the Irish Statutes S.I. No. 540/2003 - Medicinal Products (Prescription and Control of Supply) Regulations 2003 the word “dispensed” should be written or printed on the prescription when the dispensing of a prescription has been completed. Once a prescription has been completed it cannot legally be dispensed further (Irish Statute Book, 2003). Therefore, medications cannot be legally dispensed from a prescription that is indicated as fully “dispensed” already.

3.8.2 Design of Prescription Audit Data Collection Sheets

A data collection form was designed with the help of the GUIDE pharmacy staff and dissertation supervisors. The data collection sheet was used to review individual prescribing episodes for patients attending the GUIDE clinic. A prescribing episode is being defined in this study as any episode where medications are prescribed for an individual patient during a clinic session on one particular day. Patients may attend more than one clinic session during the study period and therefore have multiple prescribing episodes during the study period.

The data fields on the data collection sheet were chosen to give context to any errors found, and with the anticipation of the type of analysis that may be performed on these errors. As outlined in section 2.3.3, the UK PRACtICE study provided useful demographics which were used to compare prescribing errors (Avery et al., 2012). This helped to influence the demographic characteristics selected to be collected in this data collection. Where possible, coded data fields were used to facilitate data collection and future analysis. The potential error types were also coded, as shown in Table 3.2, to facilitate ease of use of the data collection sheet and to categorise error types.

The Health Service Executive Quality & Patient Safety Directorate (2013) advises that if audit data are collected by more than one person, the terminology should be clear and there should be no confusion surrounding it. They advise that each data item should have a definition so that it is collected consistently and there is “inter-rater reliability”. This also reflects the point made by Dean et al. (2002b) in section 2.3.3 that while prospective recording of errors by pharmacists screening prescriptions is a useful way of capturing errors, one of the main disadvantages is that variations can occur between pharmacist data collectors. For this reason, coded errors were used with details of each error type to improve inter-rater reliability. In addition, an instruction sheet was developed in order to ensure all data collectors were using the data collection sheet in the same way and to facilitate ease of data collection. The final data collection sheet used and associated instruction sheet can be seen in Appendix G.

3.8.3 Inclusion and Exclusion Criteria

The inclusion and exclusion criteria for each of the study participants can be seen in Table 3.3 below.

Table 3.3: Inclusion and exclusion criteria

Group	Inclusion criteria	Exclusion criteria
Pharmacy Staff	All pharmacy staff screening and dispensing prescriptions in the GUIDE pharmacy.	Pharmacy staff not working in the GUIDE clinic.
Patient Records	All patients attending selected GUIDE clinics on a given day.	<ul style="list-style-type: none"> • Patients for whom a prescription was not written. • Further prescribing episodes for patients who were included in either the pre-intervention or post-intervention audit were excluded to ensure all subjects were independent of each other.
Clinicians to be observed, to answer the questionnaire, and to receive the training intervention	All GUIDE clinicians who prescribe using the GUIDE electronic prescribing system.	GUIDE Senior House Officers who do not prescribe medication.

3.8.4 Pilot Audit

The data collection sheets were initially piloted in the live clinic setting with four pharmacist data collectors. Adjustments were made based on their feedback and comments. As well as adjustments to the data collection sheet itself, adjustments were made to the final list of potential errors in Table 3.2 in section 3.8.1 that were to be reviewed during data collection.

3.8.5 Pre-intervention Prescription Audit

Prior to the training intervention, data were collected for six days (Monday to Wednesday over a two-week period). This method was selected so that a variety of outpatient clinic types provided by the GUIDE clinic could be reviewed and prescribing by a variety of prescribers captured. Data were collected by five pharmacists dispensing prescriptions in the GUIDE clinic. Data were collected at the time of each patient's visit/prescription dispensing. Further prescribing episodes for patients who were already included in the pre-intervention audit were excluded. This was to prevent duplicate patients and ensure all subjects were independent of each other.

3.8.6 Questionnaire Design

A questionnaire was developed for distribution to the GUIDE prescribers to try to gain some insight into the training history of the prescribers, their interaction with the GUIDE EPR system, and to receive feedback from them. The main aim of the questionnaire was to inform and support the training intervention. It was not intended that detailed statistical analysis be carried out on the questionnaire results, particularly given the small sample size.

Following discussions with the lead clinician for the GUIDE EPR, the GUIDE pharmacy staff, and dissertation supervisors, the questionnaire was designed. Several iterations of the questionnaire were designed following review and feedback before the final questionnaire was decided upon. Qualtrics web-based survey tool (www.qualtrics.com) was used to design the questionnaire online. The online questionnaire incorporated the prescribers' Information Sheet for Prospective Participants (Appendix H) and the prescribers' Informed Consent Form (Appendix I). A copy of the questions in the online questionnaire can be seen in Appendix J.

3.8.7 Questionnaire Pilot

The questionnaire was piloted with GUIDE pharmacy staff and the lead clinician for the EPR. Due to the low number of prescribers available to carry out the final questionnaire, the only GUIDE prescriber who piloted the questionnaire was the lead clinician for the EPR. This was decided in order to maximise the number of final responses.

3.8.8 Questionnaire Distribution

The online questionnaire was distributed via email to all prescribers in the GUIDE clinic along with the prescribers' Information Sheet for Prospective Participants (Appendix H) and the prescribers' Informed Consent Form (Appendix I). The questionnaire remained open for a period of six days.

3.8.9 Clinicians Observed

Two clinicians were observed during GUIDE outpatient clinics in order to inform the training intervention, and to understand the interaction of clinicians with the system during live clinics. This was a convenience sample based on the availability of prescribers during a given clinic day.

3.8.10 Training Intervention Design

Following the pre-intervention prescription audit, a training education session was designed. The data gathered from the pre-intervention prescription audit and the questionnaire, as well as the literature, were used to help guide the training intervention design. The more frequent errors found in the prescription audit were reviewed. For any errors which could be considered to be system-related, the system was reviewed to try to understand why these errors may occur. The questionnaire results and clinician observations were used to review clinicians' interaction with the GUIDE electronic prescribing system and to gain feedback from clinicians on using the system for prescribing medications.

3.8.11 Training Intervention

The training intervention was delivered to GUIDE clinicians in an interactive classroom-based session during their weekly lunchtime education session. The training intervention was facilitated visually with a Microsoft PowerPoint presentation. The key results of the pre-intervention audit were fed back to prescribers. A more detailed analysis of the top three errors was presented to the prescribers including where in the system these errors occur, why they may be happening, and how they may be avoided. Key results of the questionnaire were also fed back and the main issues arising from this were addressed. Where knowledge of using the system functions for a particular task was highlighted as lacking in the questionnaire results, demonstrations on these system functions were presented. The presentation used to aid the delivery of the training intervention can be seen in Appendix O. A copy of this presentation was sent to all GUIDE prescribers following the delivery of the training intervention to consolidate the information presented.

3.8.12 Post-Intervention Prescription Audit

Two weeks after the delivery of the training intervention, further data were collected for eight days (Monday to Wednesday over a three-week period). The Monday of the third week was excluded as this was a public bank holiday. Two additional data collection days were included to allow for the exclusion of duplicate patients who appeared in the pre-intervention prescription audit. The same days of the week as the pre-intervention data period were selected to include the same clinic types for comparison. Data were again collected by five pharmacists dispensing prescriptions in the GUIDE clinic. Data were collected at the time of each patient's visit/prescription dispensing. Prescribing episodes for any patients who were included in the pre-intervention audit were excluded from the post-intervention audit. Further prescribing episodes for patients who were already included in the post-intervention audit were also excluded.

3.8.13 Data Management

All data gathered in the pre-intervention and post-intervention audits were entered into a Microsoft Excel spread sheet. Numeric codes were used to code the data, with the exception of the one free text data field. To minimise the incidence of reporting and input errors, the Health Service Executive Quality & Patient Safety Directorate (2013) recommends that there be routine data quality checks for audit data. Intermittent checks on the data gathered by GUIDE pharmacists were carried out by the primary researcher prior to the input of data into the Excel spread sheet. Another pharmacist working in the hospital acted as a quality checker to review a proportion of the data inputted.

The questionnaire data were collected using the Qualtrics web-based survey tool. This tool also produced a report aggregating the data and presenting answer frequency information.

3.8.14 Statistical Analysis

The statistical test carried out to compare the difference between proportions in the two populations (pre-intervention and post-intervention) was the z-score test for two population proportions. The formula for calculating the z score can be seen in the following box:

$$z = \frac{(p1 - p2)}{\sqrt{\frac{p1(1 - p1)}{n1} + \frac{p2(1 - p2)}{n2}}}$$

p1 = proportion from the first population n1 = sample size for the first population
p2 = proportion from the second population n2 = sample size for the first population

The p value was calculated using two-tailed hypothesis. The significance level applied to the results was 0.05. An online z-score calculator for two population proportions which applied this z-score formula was used. This calculator can be accessed at <http://www.socscistatistics.com/tests/ztest/Default2.aspx>. The results found using the online calculator were also validated using SPSS software. The chi-square test of independence (χ^2) was performed to compare the two population proportions (Levine, 2015). This test is closely related to the z-score test ($z^2 = \chi^2$).

3.9 Study Duration

The study took place from the 25th January 2016 to the 29th March 2016. Details of the dates during which the various research methods were carried out can be seen in Figure 3.2.

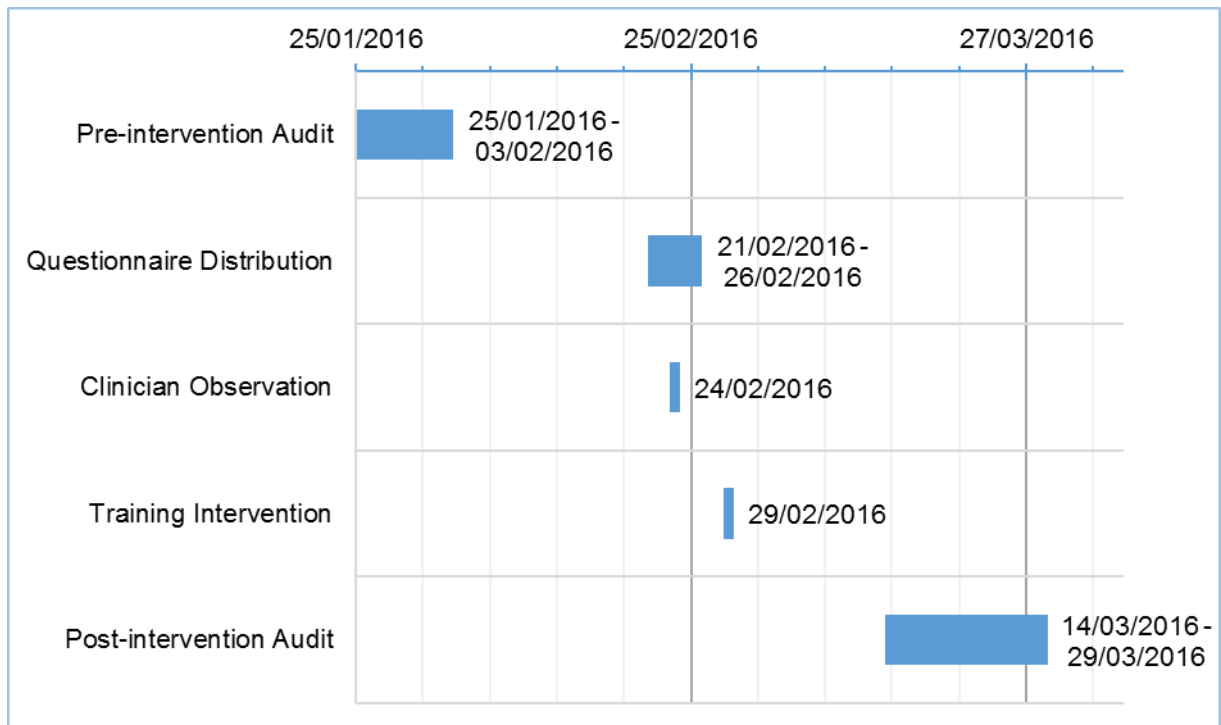


Figure 3.2: Research methods timeline

3.10 Sampling and Recruitment

3.10.1 Number of Participants

Prescription Audit

The following formula was used to calculate the minimum sample size for the pre-intervention and post-intervention audits.

$$n = [Z^2 \times \pi(1 - \pi)]/e^2$$

n = required sample size

e = acceptable sampling error

π = true proportion of “successes”

The critical Z value is determined by the desired level of confidence

The findings from the literature review were used to assign the π value for the above equation. As outlined in section 2.3.3, Ross et al. (2009) found considerable variation in the rate of prescribing errors reported, with rates ranging from 4.2% to 82% of charts or patients reviewed. In the PRACTICE study by Avery et al. (2012) in the general practice setting, 12.5% of patients had a prescribing or monitoring error. As discussed in section 2.3.3, this study is useful to compare to the research in this dissertation as it is set in the outpatient setting and all the GP practices examined had a computer system in place which was used to generate prescriptions, similar to the study setting in the GUIDE clinic. Taking this predicted error rate of 12.5%, π was assigned a value of 0.125. The desired confidence interval was taken to be 95%; therefore, Z was assigned a value of 1.96. To estimate the true proportion of errors in a large population within $\pm 5\%$, e was assigned a value of 0.05. Applying these figures to the above equation the desired sample size was estimated to be 168 ($n = [1.96^2 \times 0.125(1 - 0.125)]/0.05^2$). Given this result, it was decided that the minimum sample size for both pre-intervention and post-intervention would be 168 patients. Alternatively, if the higher error rate in the Ross et al. (2009) review of 82% was applied to this equation the desired sample size would be 227 patients.

Monday, Tuesday and Wednesday outpatient clinics in the GUIDE clinic account for the majority of clinics provided. In order to maximise capture and to review a variety of prescribers, it was decided to review the prescriptions in each of these clinics twice in the pre-intervention audit. Based on figures from 2015, on average 42 patients receive prescriptions from the GUIDE clinic per day. Therefore, it was estimated that approximately 252 patients would receive prescriptions during the six days of data collection in the pre-intervention audit. It was estimated that approximately 336 patients would receive prescriptions during the eight days of data collection in the post-intervention audit. These predicted sample size figures for the pre-intervention and post-intervention audits are above the minimum sample sizes calculated using both the 12.5% and 82% error rates outlined above.

Questionnaire

The questionnaire was designed to assist in the training intervention design. Statistical analysis was not performed on the results. All twenty-five GUIDE prescribers were contacted to complete the study questionnaire.

3.10.2 Recruitment Methods

The recruitment methods for each of the participants can be seen in Table 3.4. Informed consent was obtained from staff members recruited; this is outlined in section 3.11.3.

Table 3.4: Recruitment methods

Group	Recruitment methods
Pharmacy Staff	All pharmacy staff screening and dispensing prescriptions in the GUIDE pharmacy were requested to take part in collecting prescription data for the audits.
Patient Records	Electronic records for all patients receiving prescriptions from the GUIDE pharmacy during clinics on selected audit days were reviewed.
Clinicians to be Observed	The GUIDE clinician prescribers to be observed were selected as advised by the lead clinician for the GUIDE EPR based on their availability during a specific clinic time.
Clinicians to answer the questionnaire and receive the training intervention	All clinicians prescribing medications in the GUIDE clinic were asked to partake in the study. They were asked to participate via email and at a GUIDE clinician education session.

3.11 Ethics

3.11.1 Ethical Considerations

As the study focuses on detecting errors, ethical consideration was given to dealing with the discovery of any errors. Any clinically relevant errors discovered were relayed to the GUIDE pharmacy and/or clinicians as deemed appropriate by the lead researcher (a qualified pharmacist). This is in line with standard hospital practice for patient care and the duty of care to the patient by which the lead researcher is bound as a result of being a registered member of the Pharmaceutical Society of Ireland.

3.11.2 Legislation and Consent

The “Data Protection Guidelines on research in the Health Sector” was used as the primary source of legislative guidelines for the study design (Data Protection Commissioner, 2007). With regards to patient consent, since pseudonymised data could be used with appropriate safeguards, the advice was taken from the Data Protection Guidelines to proceed without the need for patient consent “ensuring that the key to a person’s identity (was) retained by the data controller only and not revealed to third parties”. Data was anonymised before transferring it outside the hospital for analysis.

3.11.3 Informed Consent

Informed consent was obtained from pharmacy staff members assisting in the collection of data from the electronic prescribing system. Informed consent was also obtained from the clinicians chosen to observe their interactions with the electronic prescribing system and the clinicians completing the questionnaire. Clinicians who received the training intervention received this as part of the weekly GUIDE clinician education sessions which are a part of their normal line of work and continuous professional development. The information sheets and consent forms given to pharmacy staff and clinicians can be seen in Appendix E, Appendix F, Appendix H and Appendix I.

3.11.4 Ethical Approval

Approval to proceed with the study was granted by the Risk and Legal Department in St James’s Hospital (see Appendix K) and a waiver for further ethical approval was granted by the Tallaght Hospital/St. James’s Hospital Joint Research Ethics Committee (see Appendix L). Ethical approval was also granted by the Trinity College School of Computer Science and Statistics (SCSS) Research Ethics Committee (see Appendix M and Appendix N).

3.12 Expected Outcomes

The aim of the training intervention was to reduce the prevalence of prescribing errors in the electronic prescribing system in the GUIDE clinic. In addition, the study was expected to provide information on the types of prescribing errors occurring in the GUIDE clinic before and after the training intervention.

3.13 Conclusion

Guided by the literature and input from key stakeholders, this dissertation study was designed to meet the research aim and objectives and to answer the primary research questions. Audit and feedback methodologies have been employed as the research approach. In summary, the

primary research involves a pre-intervention audit, a prescriber questionnaire, clinician observation, delivery of a training intervention, and a post-intervention audit. The next chapter shall review the findings of this research.

Chapter 4. Results

4.1 Introduction

In this chapter, the results of the primary research outlined in Chapter 3 will be described. This includes the results of the pre-training intervention prescription audit, the post-training intervention prescription audit, and the questionnaire. Details of the training intervention are also provided.

4.2 Prescription Audit Study Population

In total, 571 individual prescribing episodes were reviewed. Thirty-eight prescribing episodes were excluded as they represented further prescribing episodes for patients who were already included in either the pre-intervention or post-intervention audit. Consequently, 265 prescribing episodes, accounting for 265 patients, were included in the pre-intervention prescription audit and 268 prescribing episodes, accounting for 268 patients, were included in the post-intervention prescription audit. A flow chart of the number of prescribing episodes and patients included in the pre-intervention and post-intervention audits can be seen in Figure 4.1.

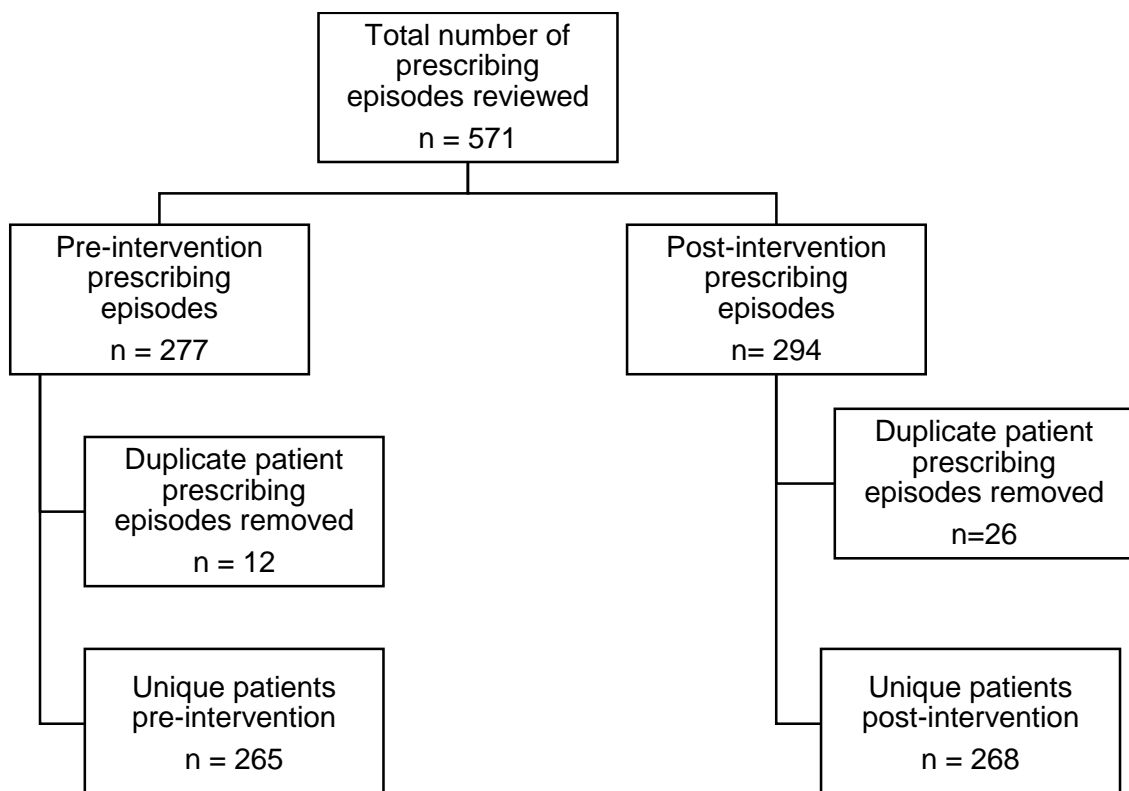


Figure 4.1: Number of prescribing episodes and patients recruited in the pre-intervention and post-intervention prescription audits and the application of exclusion criteria

4.3 Prescription Audit Results

4.3.1 Audit Demographics

Number of Patients

The demographics associated with each patient’s prescribing episode were reviewed. The purpose of this was to highlight any differences in the study population during the pre-intervention and post-intervention audits. The proportion of patients included in the study who were prescribed medications in the pre-intervention and post-intervention audits in the three clinic types can be seen in Table 4.1 and Figure 4.2. No significant difference was found between the distribution of patients prescribed medications in the HIV and viral hepatitis clinic types in the two audits. Statistically significantly more patients included in the study were prescribed medications in the STI clinic during the pre-intervention audit when compared with the post-intervention audit (13.2% versus 3.4%, $p < 0.05$).

Table 4.1: Demographic data – number of patients per clinic type who were prescribed medications

	Pre-intervention (percentage)	Post-intervention (percentage)	P value
Total number of patients	265	268	
Number of patients – HIV Clinic	177 (66.8%)	188 (70.2%)	$p = 0.40654$
Number of patients – STI Clinic	35 (13.2%)	9 (3.4%)	$p < 0.05$
Number of patients – Viral Hepatitis Clinic	53 (20.0%)	71 (26.5%)	$p = 0.07672$

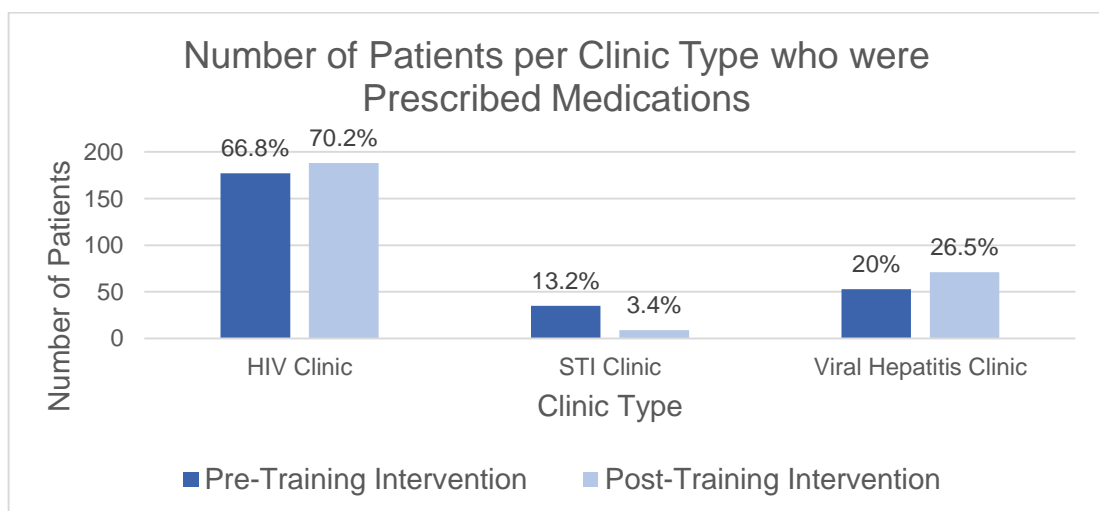


Figure 4.2: Distribution of patients per clinic type who were prescribed medications during pre-intervention and post-intervention audits

The proportion of patients prescribed medications by the five prescriber types in the pre-intervention and post-intervention audits can be seen in Table 4.2 and Figure 4.3. No significant difference was found between the distribution of patients prescribed medications by the GUM specialist, GP trainee and nurse prescriber types in the two audits. However, there were statistically significantly more patients prescribed medications by consultants during the pre-intervention audit than the post-intervention audit (62.3% versus 38.0%, $p < 0.05$). Conversely, there were statistically significantly less patients prescribed medications by registrars during the pre-intervention audit than the post-intervention audit (26.8% versus 49.3%, $p < 0.05$).

Table 4.2: Demographic data – number of patients per prescriber type who were prescribed medications

	Pre-intervention (percentage)	Post-intervention (percentage)	P value
Total number of patients	265	268	
Number of patients – Consultant Prescriber	165 (62.3%)	102 (38.0%)	p < 0.05
Number of patients – GUM Specialist Prescriber	14 (5.3%)	22 (8.2%)	p = 0.17702
Number of patients – Registrar Prescriber	71 (26.8%)	132 (49.3%)	p < 0.05
Number of patients – GP Trainee Prescriber	1 (0.4%)	4 (1.5%)	p = 0.18024
Number of patients – Nurse Prescriber	14 (5.3%)	8 (3.0%)	p = 0.18352

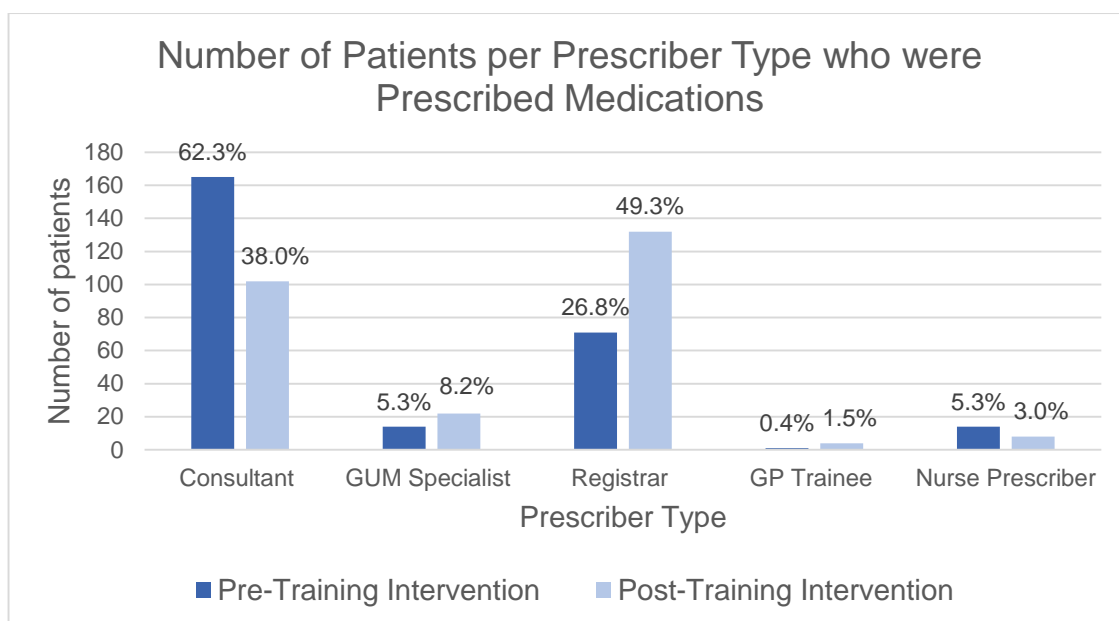


Figure 4.3: Distribution of patients per prescriber type who were prescribed medications during pre-intervention and post-intervention audits

Number of Medications Prescribed

The demographic characteristics associated with the total number of medications prescribed were also reviewed. The proportion of medications prescribed during the pre-intervention and post-intervention audits in the three clinic types can be seen in Table 4.3 and Figure 4.4. Similar to the distribution of patients, no significant difference was found between the distribution of medications prescribed in the HIV clinic in the two audits. There were statistically significantly more medications prescribed in the STI clinic during the pre-intervention audit when compared with the post-intervention audit (8.1% versus 4.1%, $p < 0.05$). There were statistically significantly more medications prescribed in the Viral Hepatitis clinic during the post-intervention audit when compared with the pre-intervention audit (32.7% versus 24.9%, $p < 0.05$).

Table 4.3: Demographic data – number of medications prescribed per clinic type

	Pre-intervention (percentage)	Post-intervention (percentage)	P value
Total number of medications prescribed	567	542	
Number of medications prescribed – HIV Clinic	380 (67.0%)	343 (63.3%)	$p = 0.1902$
Number of medications prescribed – STI Clinic	46 (8.1%)	22 (4.1%)	$p < 0.05$
Number of medications prescribed – Viral Hepatitis Clinic	141 (24.9%)	177 (32.7%)	$p < 0.05$

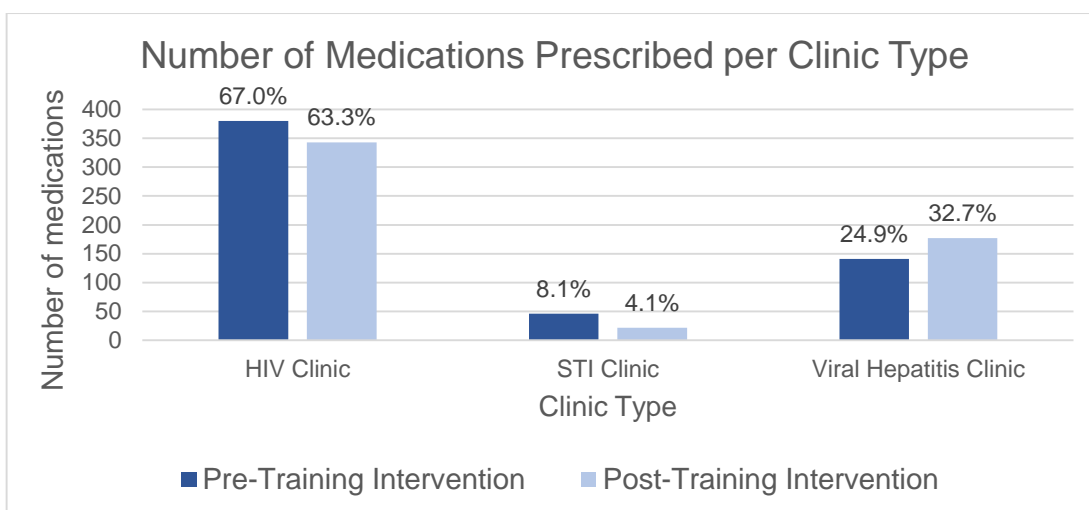


Figure 4.4: Distribution of the number of medications prescribed per clinic type during pre-intervention and post-intervention audits

The proportion of medications prescribed by the five prescriber types in the pre-intervention and post-intervention audits can be seen in Table 4.4 and Figure 4.5. No significant difference was found between the distribution of medications prescribed for the GP trainee and nurse prescriber types in the two audits. However, in line with the distribution of patients, there were statistically significantly more medications prescribed by consultants (64.0% versus 39.1%, $p < 0.05$) and less medications prescribed by registrars (28.6% versus 48.7%, $p < 0.05$) during the pre-intervention audit than the post-intervention audit. Although there was no statistical difference in the number of patients prescribed medications by GUM specialists during the two audits, there were statistically significantly less medications prescribed by GUM specialists (4.6% versus 7.4%, $p < 0.05$) during the pre-intervention audit than the post-intervention audit.

Table 4.4: Demographic data – number of medications prescribed per prescriber type

	Pre-intervention (percentage)	Post-intervention (percentage)	P value
Total number of medications prescribed	567	542	
Number of medications prescribed – Consultant Prescriber	363 (64.0%)	212 (39.1%)	p < 0.05
Number of medications prescribed – GUM Specialist Prescriber	26 (4.6%)	40 (7.4%)	p < 0.05
Number of medications prescribed – Registrar Prescriber	162 (28.6%)	264 (48.7%)	p < 0.05
Number of medications prescribed – GP Trainee Prescriber	1 (0.2%)	6 (1.1%)	p = 0.05
Number of medications prescribed – Nurse Prescriber	15 (2.6%)	20 (3.7%)	p = 0.32218

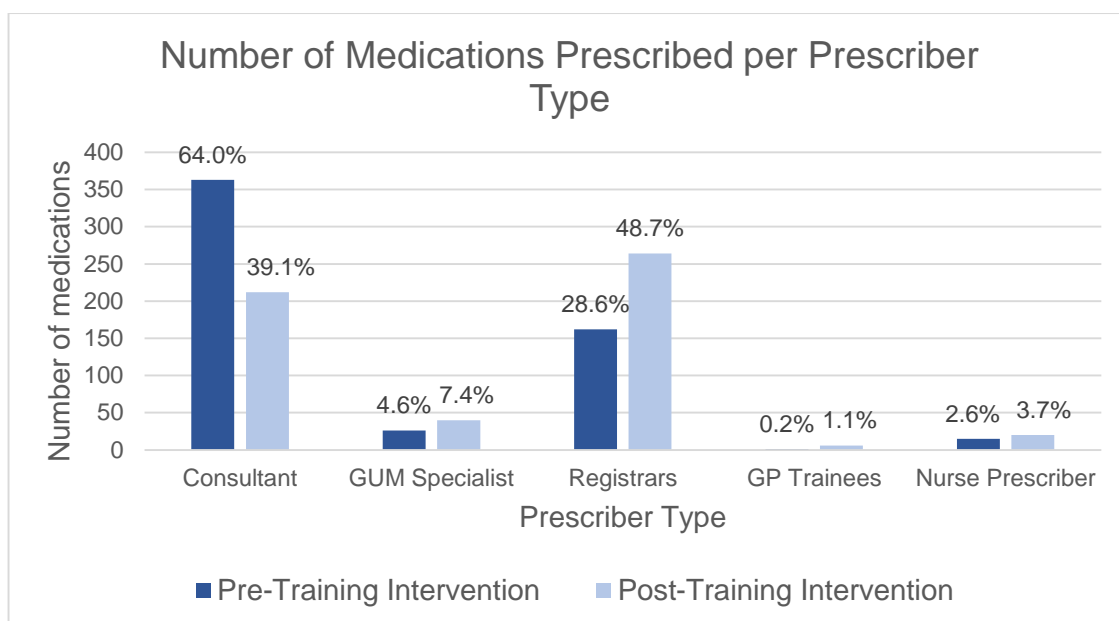


Figure 4.5: Distribution of the number of medications prescribed per prescriber type during pre-intervention and post-intervention audits

4.3.2 Error Rates and Error Specific Demographics

The rate of errors found in the pre-intervention and post-intervention audits, based on the total number of patients and the total number of medications prescribed, can be seen in Table 4.5.

Table 4.5: Error rates

	Pre-intervention	Post-intervention	P value
Total number of patients	265	268	
Number of patients whose prescription(s) contained one or more errors <i>(percentage of total patients)</i>	83 (31.3%)	39 (14.6%)	p < 0.05
Total number of medications prescribed	567	542	
Total number of medications containing one or more errors <i>(percentage of total medications prescribed)</i>	162 (28.6%)	50 (9.2%)	p < 0.05
Total number of errors found	195	67	

Since some medications contained more than one error, the total number of errors found is greater than the total number of medications containing one or more errors. Pre-intervention the rate of error was found to be 73.6 errors per 100 patients (based on the results of 195 errors in 265 patients). Following the training intervention this error rate reduced to 25 errors per 100 patients (based on the results of 67 errors in 268 patients). Statistically significantly

more patients were prescribed medications which contained one or more errors during the pre-intervention audit when compared with the post-intervention audit (31.3% versus 14.6%, $p < 0.05$), as displayed in Figure 4.6.

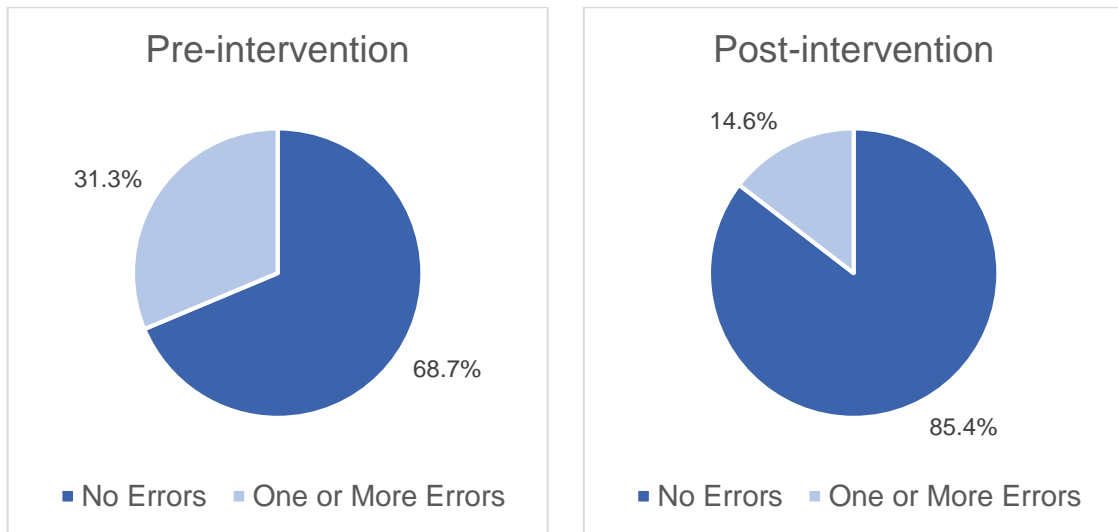


Figure 4.6: Proportion of patients who were prescribed medications which contained one or more prescribing errors

Similarly, as highlighted in Figure 4.7, significantly more medications prescribed during the pre-intervention audit contained one or more errors when compared with the post-intervention audit (28.6% versus 9.2%, $p < 0.05$).

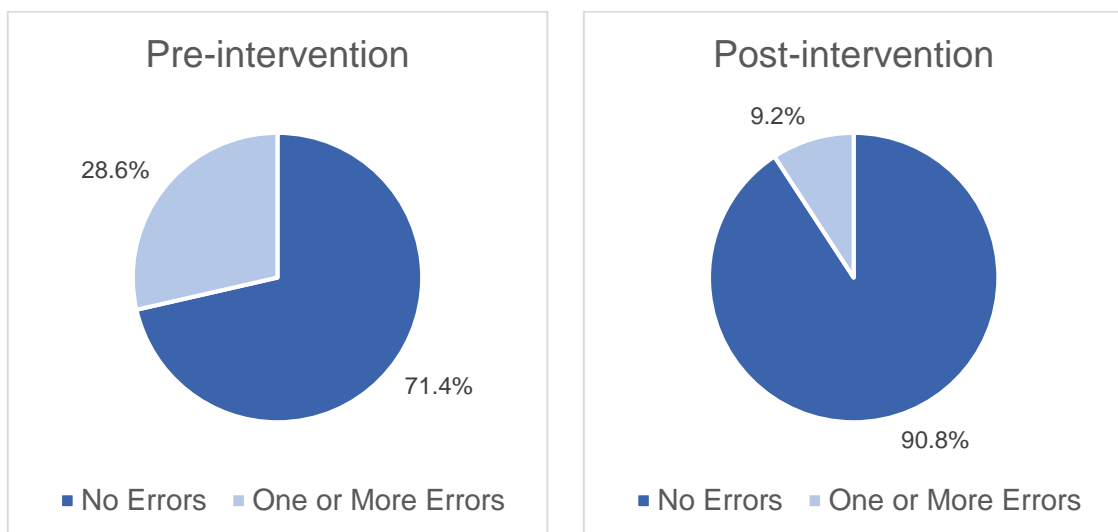


Figure 4.7: Proportion of medications prescribed which contained one or more errors

Error demographics from the pre-intervention and post-intervention audits can be seen in Table 4.6; this includes the proportion of errors found in the three clinic types and by the five prescriber types.

Table 4.6: Error demographics

	Pre-intervention (percentage total errors)	Post-intervention (percentage total errors)	P value
Total number of errors found	195	67	
Number of errors – HIV Clinic	127 (65.1%)	52 (77.6%)	p = 0.05876
Number of errors – STI Clinic	17 (8.7%)	0 (0.0%)	p < 0.05
Number of errors – Viral Hepatitis Clinic	51 (26.2%)	15 (22.4%)	p = 0.54186
Number of errors – Consultant Prescriber Type	159 (81.5%)	38 (56.7%)	p < 0.05
Number of errors– GUM Specialist Prescriber Type	10 (5.1%)	9 (13.4%)	p < 0.05
Number of errors – Registrar Prescriber Type	25 (12.8%)	16 (23.9%)	p < 0.05
Number of errors – GP Trainee Prescriber Type	0 (0.0%)	4 (6.0%)	p < 0.05
Number of errors – Nurse Prescriber Type	1 (0.5%)	0 (0.0%)	p = 0.5552
Number of errors for repeat (copied) prescriptions for which this error has happened more than once for this prescription in the patient's medication history	11 (5.6%)	5 (7.5%)	p = 0.5892

The proportion of the total errors which occurred in the STI clinic type was significantly greater in the pre-intervention audit when compared with the post-intervention audit (8.7% versus 0%, $p < 0.05$). This is in line with the results in section 4.3.1 which highlight that a significantly greater proportion of medications were prescribed in the STI clinic type in the pre-intervention audit compared to the post-intervention audit.

The proportion of the total errors which occurred by prescriptions generated by consultants was significantly greater in the pre-intervention audit when compared with the post-intervention audit (81.5% versus 56.7%, $p < 0.05$). This is in line with the results in section 4.3.1 which highlight that a significantly greater proportion of medications were prescribed by consultants in the pre-intervention audit compared to the post-intervention audit.

The proportion of the total errors which occurred by prescriptions generated by GUM specialists (13.4% versus 5.1%, $p < 0.05$), registrars (23.9% versus 12.8%, $p < 0.05$) and GP trainees (6% versus 0%, $p < 0.05$) was significantly greater in the post-intervention audit when compared with the pre-intervention audit. This also fits with the demographics outlined in section 4.3.1 which highlight that a significantly greater proportion of medications were

prescribed by GUM specialists and registrars in the post-intervention audit compared to the pre-intervention audit. However, no statistical difference was found in the proportion of medications prescribed by GP trainees in the two audits.

4.3.3 Error Type Analysis

As outlined in Table 4.5, there were 195 errors found pre-intervention in a review of 567 medications prescribed for 265 patients. In the post-intervention audit the number of errors found reduced to 67 errors in 542 medications prescribed for 268 patients. Various error types were reviewed in the prescription audits, as outlined in section 3.8.1. The distribution and proportion of the various error types in the pre-intervention and post-interventions audits can be seen in Figure 4.8 and Table 4.7.

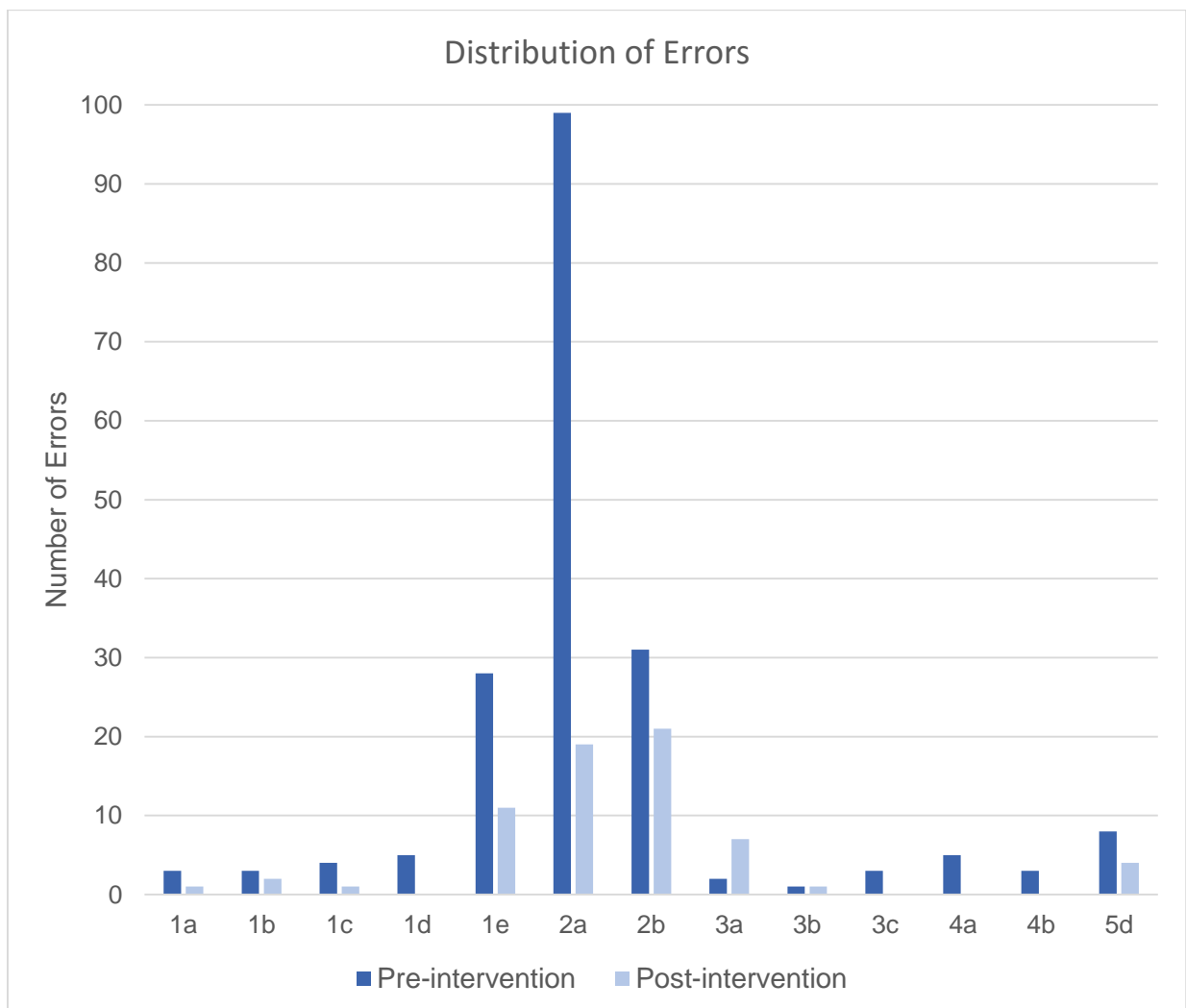


Figure 4.8: Distribution of error types in the pre-intervention and post-intervention audits

Table 4.7: Error type analysis

Error Type	Error Type Description*	Number of Errors Pre-Intervention <i>(percentage of total medications prescribed)</i>	Number of Errors Post-Intervention <i>(percentage of total medications prescribed)</i>	P value
1a	Incorrect Drug	3 (0.5%)	1 (0.2%)	p = 0.3371
1b	Incorrect Dose	3 (0.5%)	2 (0.4%)	p = 0.6892
1c	Incorrect Drug Form	4 (0.7%)	1 (0.2%)	p = 0.1971
1d	Incorrect Route	5 (0.9%)	0 (0.0%)	p < 0.05
1e	Incorrect Frequency/ Administration Details	28 (4.9%)	11 (2.0%)	p < 0.05
2a	Previous prescription copied/repeated but “dispensed status” not amended. The copied/repeated prescription indicates that the prescription is “dispensed”.*	99 (17.5%)	19 (3.5%)	p < 0.05
2b	Details in “order comments” or “special instructions” field copied/repeated from previous prescription that are no longer valid/appropriate.	31 (5.5%)	21 (3.9%)	p = 0.2113
3a	Patient waiting for medications but no order received by GUIDE pharmacy due to omission of prescription.	2 (0.4%)	7 (1.3%)	p = 0.0819
3b	Patient waiting for medications but no order received by GUIDE pharmacy due to omission of task creation.	1 (0.2%)	1 (0.2%)	p = 0.9761
3c	GUIDE pharmacy task generated but no note and no prescription attached.	3 (0.5%)	0 (0.0%)	p = 0.0891
4a	Pre-pack* prescription selected but the prescription is intended to be dispensed in the GUIDE pharmacy.	5 (0.9%)	0 (0.0%)	p < 0.05
4b	Task received in the GUIDE pharmacy to dispense prescription but the prescription was already dispensed as a pre-pack* by the prescriber.	3 (0.5%)	0 (0.0%)	p = 0.0891
5d	Inappropriate prescription for other clinical reason.*	8 (1.4%)	4 (0.7%)	p = 0.2801

*See Table 3.2 for further information on the error type descriptions for error types 2a, 4a, 4b and 5d.

No errors from error types 5a (clinical error related to drug-drug interaction), 5b (clinical error related to patient's allergy status), or 5c (clinical error related to patient's renal function) in Table 3.2 were found in either audit. As described in section 3.8.11, the top three errors which occurred in the pre-intervention audit were targeted during the training intervention with prescribers. These errors were error types 2a (copied "dispensed" status), 2b (copied "order comments" no longer valid/appropriate) and 1e (incorrect frequency/administration details). The following sections shall review these error types in more detail.

4.3.4 Error Type 2a (copied "dispensed" status)

The most frequently occurring error in the pre-intervention audit was error type 2a, occurring in 99 of the 567 medications prescribed (17.5%). The frequency of this error type reduced significantly ($p < 0.05$) in the post-intervention audit, occurring in 19 of the 542 medications prescribed (3.5%), as shown in Table 4.7. This error is due to a previous prescription being copied/repeated but the prescriber did not amend the "dispensed status". The copied/repeat prescription therefore indicates that the prescription is "dispensed". The "dispensed status" field indicates whether a prescription is dispensed, partially dispensed or not dispensed. When dispensed prescriptions are copied/repeated, the prescriber must actively remove the selection of "dispensed" from the "dispensed status" field. An example of a prescription from the pre-intervention audit highlighting this error type can be seen in Figure 4.9.

Raltegravir (Raltegravir tablets)

Order 26/01/2016 11:27
Entered and electronically signed by [redacted] on 26/01/2016 at 11:27.

Status
Order Status:

Details
Strength Dose
Strength Dose Unit
Route of Administration
Frequency
As required
Requested Start Date/Time
Duration
Duration Unit
Stop Type
Constant Indicator
Dispense status

Figure 4.9: Example of error type 2a

This error type accounted for 50.8% of all errors (99 out of 195 errors) in the pre-intervention audit. The majority of this error type in the pre-intervention audit occurred in the HIV clinic (69.7%) and by consultant prescribers (88.9%). In the post-intervention audit, this error type accounted for 28.4% of all errors (19 out of 67 errors). Similar to pre-intervention, the majority of this error type post-intervention occurred in the HIV clinic (84.2%) and by consultants (78.9%).

4.3.5 Error Type 2b (*copied "order comments" no longer valid/appropriate*)

The second most common error in the pre-intervention audit was error type 2b. Error type 2b also occurs when prescriptions are copied/repeated and not correctly amended. In this case, the error arises when details in "order comments" or "special instructions" field are copied/repeated from a previous prescription but are no longer valid/appropriate for the new prescription. As shown in Table 4.7, this error occurred in 31 of the 567 medications prescribed (5.5%) in the pre-intervention audit. The frequency of this error type reduced in the post-intervention audit, occurring in 21 of the 542 medications prescribed (3.9%). This reduction, however, was not deemed to be statistically significant ($p = 0.2113$).

An example of error type 2b can be seen in Figure 4.10. In this example a comment was entered in July 2015 stating the prescription was not to be dispensed until results of a chest x-ray were received. This comment was then copied with the prescription in January 2016 when this instruction was no longer indicated.

This error type accounted for 15.9% of the total errors (31 out of 195 errors) in the pre-intervention audit and 31.3% (21 out of 67 errors) in the post-intervention audit. Similar to error type 2a, the majority of 2b errors in the pre-intervention and post-intervention audits were in the HIV clinic type (90.3% and 85.7% respectively) and prescribed by consultants (64.5% and 47.6% respectively). In 12.9% of these errors pre-intervention, and 14.3% post-intervention, the same error had occurred more than once for that prescription in the patient's medication history. This means the comment was copied in error more than once.

Darunavir (Darunavir tablets)

Order 25/01/2016 16:58
 Entered and electronically signed by [redacted] on 25/01/2016 at 16:58.

Status
 Order Status:

Details

Strength Dose	<input type="text" value="800"/>
Strength Dose Unit	<input type="text" value="mg"/>
Route of Administration	<input type="text" value="Oral"/>
Frequency	<input type="text" value="once a day"/>
As required	<input type="text" value="No"/>
Requested Start Date/Time	<input type="text" value="25/01/2016 16:58"/>
Duration	<input type="text" value="1"/>
Duration Unit	<input type="text" value="month(s)"/>
Stop Type	<input type="text" value="Physician Stop"/>
Constant Indicator	<input type="text" value="No"/>

Comment
 dont dispense until CXR reviewed

Figure 4.10: Example of error type 2b

4.3.6 Error Type 1e (*incorrect frequency/administration details*)

The third most common error in the pre-intervention audit was error type 1e. Error type 1e indicates the incorrect frequency and/or administration details were prescribed. Many of these errors arose from prescriptions where a medication which should be prescribed at a fixed dose was prescribed “as directed” and/or “as required”. This error occurred in 28 of the 567 medications prescribed (4.9%) in the pre-intervention audit. The frequency of this error type reduced significantly ($p < 0.05$) in the post-intervention audit, occurring in 11 of the 542 medications prescribed (2.0%).

This error type accounted for 14.4% of the total errors (28 out of 195 errors) in the pre-intervention audit and 16.4% (11 out of 67 errors) in the post-intervention audit. This error type occurred with a more scattered distribution among the different clinic types. The HIV clinic accounted for 46.4% of these errors pre-intervention and 54.5% post-intervention. The viral hepatitis clinic accounted for 32.1% and 27.3% in the pre-intervention and post-intervention respectively, while the STI clinic accounted for 21.4% and 0% in the pre-intervention and post-intervention respectively. The majority of these errors were in prescriptions generated by consultants; they accounted for 67.9% and 81.8% of these errors in the pre-intervention and post-intervention respectively.

An example of this error type can be seen in Figure 4.11. In this example, an anti-retroviral medication (ribavirin), which requires a specified fixed dosing interval, was prescribed “as directed” and “as required” in error. This was subsequently amended by the prescriber to a regular dosing frequency of twice daily.

Details	After	Before
Frequency	twice a day	As directed

Order	26/01/2016 12:29
Entered and electronically signed by [redacted] on 26/01/2016 at 12:28.	
Status	Order Status: Ordered
Details	
Strength Dose	400
Strength Dose Unit	mg
Route of Administration	Oral
Frequency	As directed
As required	Yes
Duration	5
Duration Unit	month(s)
Requested Start Date/Time	26/01/2016 12:29
Stop Type	Physician Stop
Constant Indicator	No
As required reason	OTHER: See Order Comments

Figure 4.11: Example of error type 1e (1)

Another example of error type 1e can be seen in Figure 4.12. In this example an antibiotic medication (co-amoxiclav) was prescribed for 5 weeks in error when it was intended to be a short course of 5 days.

Co-amoxiclav (Augmentin tablets)

Order	26/01/2016 15:04
Entered and electronically signed by [redacted] on 26/01/2016 at 15:04.	
Status	
Order Status:	Ordered
Details	
Strength Dose	625
Strength Dose Unit	mg
Route of Administration	Oral
Frequency	three times a day
Duration	5
Duration Unit	week(s)
Requested Start Date/Time	26/01/2016 15:04
Stop Date/Time	01/03/2016 15:03
Stop Type	Physician Stop
Constant Indicator	No

Figure 4.12: Example of error type 1e (2)

4.3.7 Other Error Types

The three most common errors, 2a, 2b and 1e mentioned above, accounted for 81% of all errors found in the pre-intervention audit and 76.1% of all errors found in the post-intervention audit. Of the other errors found, the frequency of two of the error types, error types 1d and 4a, were found to be statistically significantly reduced from the pre-intervention to the post-intervention audits. Error type 1d indicates the incorrect route was prescribed. This error reduced from an incidence of 0.9% in the pre-intervention audit, to 0% in the post-intervention audit ($p < 0.05$). Error type 4a arises when a pre-pack prescription is prescribed but the prescription is intended to be dispensed in the GUIDE pharmacy. Pre-pack prescriptions are those medications which may be prescribed and dispensed to GUIDE patients by the prescriber directly. They include single doses of certain once off prescriptions and commonly prescribed short courses of treatment. The incidence of error type 4a also reduced from 0.9% in the pre-intervention audit, to 0% in the post-intervention audit ($p < 0.05$). It is noted that neither of these error types were targeted or discussed in the training intervention.

Error type 1b represented incorrect dose selection. Error type 1b accounted for 1.5% of all errors in the pre-intervention audit (3 out of 195 errors) and 3.0% of all errors in the post-intervention audit (2 out of 67 errors).

Error type 5d accounted for inappropriate prescriptions for clinical reasons other than a drug-drug interaction, patient's allergy status, or patient's renal function. The majority of these errors in both the pre-intervention and post-intervention audits occurred due to an omission of a required medication, such as an antiretroviral or a prophylactic medication for pneumocystis pneumonia. Other examples of this error type included prescribing a medication that was no longer required and duplicating a prescription. There was no significant difference in the frequency of this error type between the pre-intervention and post-intervention audits ($p = 0.2801$).

4.3.8 Prescription Type

When prescribing medications electronically in the GUIDE electronic prescribing system, prescriptions can be either entered as a new prescription or a previous prescription can be copied/repeated. If a previous prescription is copied/repeated, the information associated with the prescription must be reviewed and amended, as appropriate, by the prescriber before it is electronically signed. In particular, as outlined in sections 4.3.4 and 4.3.5, the "dispensed" status field, "order comments" field and "special instructions" field must be reviewed and amended as appropriate. The majority of errors in both the pre-intervention audit (85.6%) and post-intervention audit (74.6%) were as a result of copied/repeat prescriptions. Of the 167 copied/repeat prescriptions containing an error in the pre-intervention audit, 11 (6.6%) of them had occurred more than once for that prescription in the patient's medication history. In the post-intervention audit, for 5 (10%) of the 50 copied/repeat prescriptions containing an error, that error had occurred more than once for that prescription in the patient's medication history.

Electronic prescriptions in the GUIDE clinic are usually generated for drugs which are available in the drug catalogue in the GUIDE electronic prescribing system. In some cases, drugs may be prescribed which are not available in the drug catalogue. These are known in the system as "free-text" prescription orders. In total two "free-text" prescriptions were prescribed in the pre-intervention audit; neither of these prescriptions contained an error. One "free-text" prescription was prescribed in the post-intervention audit. This "free-text" prescription had an error type 1e due to the selection of the incorrect unit of frequency.

4.4 Questionnaire Results

In total twenty-five prescribers were contacted via email to participate in the questionnaire. Seventeen prescribers (68%) responded to the request to participate and gave informed consent. All seventeen respondents completed the questionnaire. The details of all responses from the questionnaire can be seen in Appendix P.

As outlined in section 3.8.6, the main aim of the questionnaire was to inform and support the training intervention. Given the small sample size, it was not intended that detailed statistical analysis be carried out on the questionnaire results.

Of the 17 respondents, 11 (65%) reported using the GUIDE EPR to prescribe medications for more than two years. The majority of respondents (76%) reported last receiving training on how to use the GUIDE electronic prescribing system more than six months ago. Almost all respondents (94%) reported that, overall, they prefer prescribing medications on the GUIDE electronic prescribing system electronically than on paper using handwriting. The majority of respondents' (69%) preferred training method was reported to be one-to-one training with the lead clinician for the GUIDE EPR.

When asked about their interaction with the GUIDE electronic prescribing system, 10 (67%) of the 15 respondents to this question stated that, for patients who require a repeat prescription of their previously prescribed medications, they prefer to copy prescriptions from the previous entry than to enter them as original prescriptions. The main reasons reported for this included prescribers believing this method is quicker and has less potential for error.

Error type 2a relates to the legal requirement to remove the word "dispensed" from the "dispensing status" field of copied prescriptions in order to make them valid. When asked whether they were aware of this legal requirement in relation to the dispensed status, 7 (41%) of the 17 respondents reported they were not aware, as demonstrated in Figure 4.13. One prescriber outlined that they were aware of the need to remove the word "dispensed" from the "dispensing status" field of copied prescriptions but stated they were not aware this was for legal reasons.

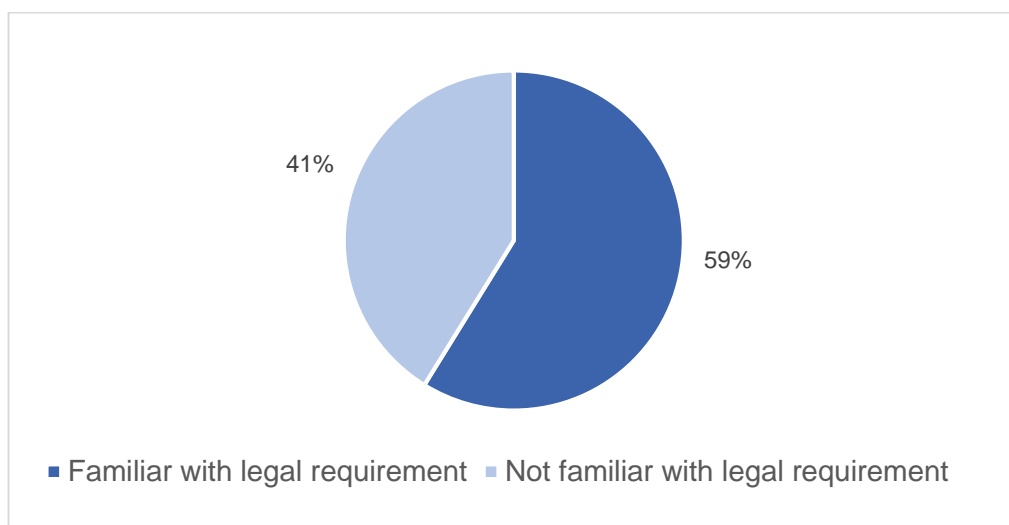


Figure 4.13: Proportion of questionnaire respondents familiar with the legal requirement to amend dispensed status

4.5 Clinician Observation

As outlined in section 3.8.9, two clinicians were observed during GUIDE outpatient clinics. The clinicians observed were a GUM specialist and a GUIDE registrar. The clinician observations were used to inform the training intervention by demonstrating prescribers' interactions with the system to the researcher. Formal findings from these observations were not gathered or analysed.

4.6 Training Intervention

In total twenty-two clinicians attended the prescriber training intervention. These included all types of prescribers, as well as senior house officers who work in the GUIDE clinic but do not prescribe medications on the GUIDE electronic prescribing system to outpatients.

The training session which was held during a weekly lunchtime education session, lasted fifty minutes. As outlined in section 3.8.11, more detailed analysis of the top three errors, error types 2a (copied "dispensed" status), 2b (copied "order comments" no longer valid/appropriate) and 1e (incorrect frequency/administration details), were presented to the prescribers. Key results of the questionnaire which were considered relevant to the training intervention were fed back to prescribers. This included the awareness of the legal requirement to amend the dispensed status, as outlined in section 4.4, which is linked with error type 2a. The presentation which facilitated the training intervention (presented in Appendix O) was emailed to all prescribers following the training intervention.

4.7 Conclusion

The results of the study have shown that overall the rate of prescribing errors reduced from 73.6 errors per 100 patients in the pre-intervention audit to 25 errors per 100 patients in the post-intervention audit. Statistically significantly more patients were prescribed medications which contained one or more errors during the pre-intervention audit when compared with the post-intervention audit (31.3% versus 14.6%, $p < 0.05$). Similarly, significantly more medications prescribed during the pre-intervention audit contained one or more errors when compared with the post-intervention audit (28.6% versus 9.2%, $p < 0.05$).

The three most common errors found in both the pre-intervention and post-intervention audits were error types 2a (copied "dispensed" status), 2b (copied "order comments" no longer valid/appropriate) and 1e (incorrect frequency/administration details). These accounted for 81% of all errors found in the pre-intervention audit and 76.1% of all errors found in the post-intervention audit. The prevalence of error types 2a and 1e were statistically significantly

reduced following the training intervention. The prevalence of error type 2b was reduced following the training intervention, but this result was not statistically significant.

The next chapter discusses these results and reviews them in light of what is known from the literature review.

Chapter 5. Evaluation and Analysis

5.1 Introduction

In Chapter 4, the results of the pre-intervention and post-intervention audits were presented, as well as the outcomes of the questionnaire and training intervention. These results are discussed in this chapter in order to answer the research questions and reflect on the literature reviewed in Chapter 2.

5.2 Prevalence of Prescribing Errors

The first research question was to assess the effect of the training intervention on the prevalence of prescribing errors for prescriptions generated by the electronic prescribing system. As outlined in section 4.3.2, this research found that there was a significant reduction in both the number of patients whose prescriptions contained one or more errors, and in the total number of medications prescribed containing an error following the training intervention. These results suggest that the training intervention has impacted positively on the rates of prescribing errors. However, it is noted that confounding factors may also have influenced the results, and therefore must be considered when interpreting the results. These confounding factors are discussed in section 6.3.

The UK PRACTICE study was used as a comparator study, as discussed in sections 2.3.3 and 3.10.1. In this study, 12.5% of the 1,777 patients had a prescribing or monitoring error which involved approximately 5% of all the prescription items reviewed. Both the pre-intervention and post-intervention results of this dissertation study revealed higher rates of prescribing errors than the PRACTICE study. The discrepancy in error rates may be related to the specific electronic prescribing system used in the GUIDE clinic. The two main error types in this study, error types 2a (copied “dispensed” status) and 2b (copied “order comments” no longer valid/appropriate), can be related to the GUIDE electronic prescribing system; this is discussed further in section 5.3. In addition, error type 2a (copied “dispensed” status) is influenced by the specific Irish legislation and the fact that pharmacists endorse the dispensed status on the electronic prescribing system in the GUIDE clinic. In the PRACTICE study, the GPs used a computer system to generate prescriptions; however, the prescriptions were printed and the pharmacy did not have access to amend the dispensed status on the same computer system, which eliminates the possibility of this error type 2a. The PRACTICE study uses the Dean et al. (2000) definition of a prescribing error. However, unlike this dissertation research, the PRACTICE study does not account specifically for system-related errors in their interpretation of a prescribing error. This may contribute to the discrepancy in error rates found.

Pre-intervention the rate of error was found to be 73.6 errors per 100 patients. Following the training intervention this error rate reduced to 25 errors per 100 patients. In the review by Westbrook et al. (2013), outlined in section 2.4.1, of two electronic prescribing systems, the rate of prescribing errors identified was found to be 185 errors per 100 patient admissions. It is noted that, in contrast to this dissertation study, the study by Westbrook et al. (2013) was a review of the medications ordered for patients during inpatient admissions. Therefore, the number and types of medications prescribed and potential error types are different than the dissertation study which reviews outpatient prescriptions in a specialist clinic. The duration of admissions or number of medications prescribed is not outlined in the Westbrook et al. (2013) study which makes interpretation of this study, and comparisons with the dissertation study, difficult. However, it can be seen that the rates of error in this dissertation study, both before and after the training intervention, are much lower than those in the Westbrook et al. (2013) study.

The error types included in the dissertation research are influenced by the definitions chosen to define a prescribing error in the research. As discussed in section 2.3.2, there is great variance in error definitions reported in other studies. This makes it difficult to compare the results of this study with other studies. This dissertation study introduces an electronic prescribing system and has included system-related errors in the definition of a prescribing error. Different error types, particularly in relation to the specific electronic prescribing system in place in the GUIDE clinic, may occur in this study which may not have been included in other studies. In particular, it is likely that error types 2 (errors associated with copying a prescription), 3 (errors in receipt of task by GUIDE pharmacy) and 4 (errors relating to pre-pack medicines) in Table 3.2, would not have been included or occurred in many of the other studies reviewing prescribing error rates. Therefore, caution must be exercised when comparing prescribing error rates in this study with other studies.

5.3 Prescribing Error Types

The second research question was to assess the effect of the training intervention on the types of prescribing errors for prescriptions generated by the electronic prescribing system. Three error types, error types 2a (copied “dispensed” status), 2b (copied “order comments” no longer valid/appropriate), and 1e (incorrect frequency/administration details), accounted for the majority of all errors found in both the pre-intervention and post-intervention audits. Although the types of prescribing errors before and after the training intervention were broadly similar, the rate of certain errors was different following the training intervention. In this section the three main error types will be discussed in more detail in the context of the prescribing error definitions and the literature reviewed in Chapter 2.

As outlined in section 2.3.4, in order to reduce the risk of medication errors, the European Medicines Agency Pharmacovigilance Risk Assessment Committee (2015a) outline that it is essential to understand the contributing factors of an error, particularly if it is occurring continuously or with the same pattern. In doing so, the Committee suggest that mitigating actions and solutions should be understood in order to prevent reoccurrence of the error. As part of the following review of the error types, an attempt has been made to try to understand the contributing factors for the main error types.

5.3.1 Error Type 2a (*copied “dispensed” status*)

The situations that may and may not be included as prescribing errors as per the Dean et al. (2000) definition of a prescribing error are outlined in Appendix B. Error type 2a, which is related to copying the “dispensed” status of the prescription, does not technically fit any of the 27 situations that should be included as a prescribing error according to Appendix B. However, this error could be seen as an error in prescription writing, or “an ambiguous medication order”, as it can lead to confusion as to whether the prescription has already been dispensed or not. Furthermore, this error is a legal error as outlined in section 3.8.1. A prescription stating that the medications have already been dispensed renders it invalid according to the Irish prescription legislation (Irish Statute Book, 2003).

In addition, this can be seen as a system-related error in line with the Westbrook et al. (2013) definition. As per this definition, there is “a high probability that the functionality or design of the electronic prescribing system contributed” to error type 2a. The design of the GUIDE electronic prescribing system results in copied/repeat prescriptions having all of the attributes of the previous prescription, including the “dispensed status” indicating that the prescription is “dispensed”. The system requires prescribers to manually change the “dispensed status” on copied/repeat prescriptions to indicate the prescription has not been dispensed. In line with the definition, “there (is) little possibility that another cause...produced the error”, other than the system design. If the prescription was paper-based, the word “dispensed” would be handwritten onto the prescription by the pharmacy at the time of dispensing and the prescription kept in that pharmacy. If the prescriber was repeating the prescription, a new paper prescription would be written/printed which would not have any indication on it that the prescription was “dispensed”.

While the training intervention appears to have positively impacted on this error type, it is conceivable that this error type could be completely eliminated with a system solution. In line with the Reason (2000) “Swiss cheese” model discussed in section 2.3.4, insufficient system defences and latent conditions could be attributed to the design of the GUIDE electronic prescribing system which may be contributing to this error type. These latent conditions when

combined with active failures of prescribers (when they fail to review and amend the “dispensed status” when prescribing a medication) may be the source of this error type. If the electronic prescribing system prevented the previous “dispensed status” from being copied for repeat prescriptions, this error would not occur. This forcing functionality would remove the latent conditions in the system and put in place a strong system defence.

Many of the prescribers who responded to the questionnaire were not aware of the legal requirement to remove the word “dispensed” from the “dispensing status” field of copied prescriptions in order to make them valid. During the training intervention the details of this error type were explained. Following the training intervention, the frequency of error type 2a was significantly reduced. A lack of knowledge or skill was highlighted in section 2.3.4 as an underlying factor that may contribute to prescribing errors (Velo and Minuz, 2009). The approach taken in the training intervention, as recommended in the literature, was to reduce prescribing errors through active interventions focused on the education of prescribers (Velo and Minuz, 2009, Avery et al., 2012, Wittich et al., 2014). The training intervention focused on informing prescribers about the legal implications of this error type in order to bridge the knowledge gap identified in the questionnaire.

It was stated in section 3.5.1 that it is beyond the scope of this particular study to assign the clinical significance to particular errors or to analyse the level of impact of errors on the patient. However, it can almost certainly be said that this error type would not have any clinical impact on the patient themselves. This error type would therefore most likely not fall into the Dean et al. (2000) definition of a prescribing error. However, as noted by Velo and Minuz (2009), this definition is concerned mostly with the outcome of the error and does not consider failures that may occur during the entire prescribing process, independent of any actual or potential harm. Rather than impacting on the patient, this error impacts upon legislative requirements and pharmacy workflow. This error type impedes workflow as further action is required before the prescription can be dispensed, which adds to the workload involved in dispensing a prescription.

5.3.2 Error Type 2b (*copied “order comments” no longer valid/appropriate*)

Error type 2b, relating to copied “order comments” or “special instructions” which are no longer valid or appropriate, could be considered as a prescribing error according to the Dean et al. (2000) definition. This error could be considered to be “an ambiguous medication order”, which is one of the situations to be considered as part of this definition, as outlined in Appendix B. Comments which are no longer valid may lead to confusion or uncertainty regarding the instructions for the current prescription.

Similar to error type 2a (copied “dispensed” status), error type 2b (copied “order comments” no longer valid/appropriate) can be seen as a system-related error in line with the Westbrook et al. (2013) definition. As mentioned above, the design of the GUIDE electronic prescribing system results in copied/repeat prescriptions having all of the attributes of the previous prescription, including the details in the “order comments” or “special instructions” fields. The system requires prescribers to manually change or remove the details in the “order comments” or “special instructions” fields on copied/repeat prescriptions to ensure they are valid and appropriate. Similar to error type 2a, as per the Westbrook et al. (2013) definition, there is “a high probability that the functionality or design of the electronic prescribing system contributed” to error type 2b. The design of the GUIDE electronic prescribing system results in the “order comments” being stored in a separate tab on the screen than the prescribed drug details. This means the “order comments” are not visible on the prescriber’s default screen when signing the copied/repeat prescription. Prescribers must remember to click the relevant tab to review “order comments” before signing the prescription. Furthermore, the design of the system also means that if an “order comment” is associated with only one medication, and more than one medication is being prescribed, then the “order comment” does not appear on either the prescriber’s default screen when signing the copied/repeat prescription, or the main tab to view “order comments” related to all prescriptions. The prescriber must drill down further in the system to view each individual drug separately to find these types of “order comments”. This can make it difficult for prescribers to know that the error is occurring. As shown in Figure 2.1 in section 2.3.4, complex procedures or faulty systems may contribute to prescribing errors. In the case of error type 2b, the process of reviewing and amending order comments could be seen as a complex procedure.

Following the training intervention, which highlighted why and how this error can occur, the frequency of this error type 2b was reduced. However, this reduction was not considered to be statistically significant. As mentioned above, this error is strongly related to the design of the system and the visibility of the error to prescribers. In the same way as error type 2a, and in line with the Reason (2000) “Swiss cheese” model, latent conditions combining with active failures of prescribers (when they fail to review and amend “order comments” when prescribing a medication) may be the source of this error type. The training intervention was used to educate prescribers about this error type but no intervention was made addressing the system design. System-related error minimisation strategies, such as designing systems to make it easier for people to do the right thing and harder to do something wrong, were highlighted in section 2.3.5 as key strategies to reduce prescribing errors. Given the strong influence of system design on this error type, a redesign of the system is likely to be more beneficial in reducing this error type than a training intervention. By preventing previous “order comments”

or “special instructions” from being copied for repeat prescriptions, a forcing functionality would be put in place to remove this error type. In addition, improving the visibility of “order comments” or “special instructions” to prescribers may be beneficial.

5.3.3 Error Type 1e (*incorrect frequency/administration details*)

Error type 1e occurs when the incorrect frequency and/or administration details are prescribed. Many of these errors arose from prescriptions where a medication which should be prescribed at a fixed dose was prescribed “as directed” and/or “as required”. In contrast to error types 2a (copied “dispensed” status) and 2b (copied “order comments” no longer valid/appropriate), which are related specifically to the electronic prescribing system, error type 1e (incorrect frequency/administration details) may occur on both handwritten paper prescriptions and electronic prescriptions. Therefore, this error type may fit with either the Dean et al. (2000) definition of a traditional prescribing error or the Westbrook et al. (2013) definition of a system-related error.

According to the situations to be considered as part of the Dean et al. (2000) definition of a prescribing error outlined in Appendix B, error type 1e could be considered to be “prescribing a dose that is not that intended” or “writing an ambiguous medication order”. Although error type 1e (incorrect frequency/administration details) is not specifically related to the drug dose, since error type 1b was attributed to the wrong dose being prescribed, error type 1e may result in an incorrect dose. If the frequency or duration of treatment is incorrect, the cumulative daily dose, or dose over a period of time, would be incorrect. If a medication that should be prescribed at a fixed dose is prescribed “as directed” and/or “as required”, this results in an ambiguous medication order.

Error type 1e may also fall under the category of “prescribing a dose regimen (dose/frequency) that is not that recommended for the formulation prescribed”. According to Appendix B, this situation may be considered as a prescribing error (depending on the individual clinical situation) as per the Dean et al. (2000) definition of a prescribing error. Anti-retroviral drugs are among the most common drugs prescribed in the GUIDE clinic. Anti-retroviral drugs should be taken at fixed dosing intervals and therefore not prescribed “as directed” and/or “as required”.

Error type 1e may also occur as a result of the electronic prescribing system itself and fall into the category of system-related errors. For example, Figure 4.12 in section 4.3.6 shows an antibiotic medication which was prescribed for 5 weeks in error when it was intended to be a short course of 5 days. This may have occurred due to a selection error from the drop-down menu, whereby weeks was selected instead of days. It was beyond the scope of this research

to review whether or not errors which may or may not be system-related errors were caused by the functionality or design of the system.

As the training intervention was focused on prescribers' interaction with the electronic prescribing system, the system was analysed, in preparation for the intervention, to establish why this error type may be happening. As outlined above, in some cases it was thought that the error may be occurring due to selection error. Alternatively, it may have been an active failure by the prescriber unrelated to the electronic prescribing system. During the analysis, it was not possible for the researcher, the lead clinician for the GUIDE EPR, or the two senior pharmacists consulted to establish why drugs with fixed dosing intervals were being prescribed "as directed" and/or "as required". This was particularly puzzling as there are order sentences with fixed dosing intervals available for all the commonly prescribed medications in the GUIDE clinic. It would require a prescriber to actively enter information in order for the drug to be prescribed "as directed" or "as required". This issue was discussed with prescribers during the training intervention and a request was made that they report to the researcher or lead clinician for the GUIDE EPR if they discovered any reason why this error may be occurring. As discussed, a lack of skill or knowledge may contribute to prescribing errors. It appeared in the training intervention that many of the prescribers were not aware that there were incidences of medications which require a fixed dosing interval being prescribed "as directed" and/or "as required". By highlighting this error in the training intervention, it was hoped that prescribers would be more aware that this error may occur and would check for this error before signing a prescription. The frequency of error type 1e did reduce significantly following the training intervention.

5.3.4 Other Error Types

Error type 4a (related to pre-pack prescriptions) was significantly reduced following the training intervention. Pre-pack prescriptions are most commonly prescribed in the STI clinic type. It is noted that the number of medications prescribed in the STI clinic type was significantly reduced in the post-intervention audit when compared with the pre-intervention audit. Given that error type 4a was not specifically addressed in the training intervention, it is likely that the reduction in the number of medications prescribed in the STI clinic had a greater influence on the reduction in this error type than the training intervention.

In this dissertation study, incorrect dose selection was attributed to error type 1b. Error type 1b accounted for 1.5% of all errors in the pre-intervention audit and 3.0% of all errors in the post-intervention audit. As mentioned in section 5.3.3, error type 1e (incorrect frequency/administration details) may also result in an incorrect dose. Error type 1e accounted for 14.4% and 16.4% of all errors in the pre-intervention and post-intervention audits respectively;

however, not all of these errors may be dose related. In the literature, included among the most common prescribing errors reported were those related to incorrect dose selection. Velo and Minuz (2009) report that over 50% of all prescribing faults are due to errors in dose selection. In the Dean et al. (2002b) study investigating the incidence of prescribing errors in inpatients in a UK hospital, 54% of errors were associated with dosing choice.

The discrepancy in dosing error rates between the literature and this study may be related to the fact that the high rate of dose selection errors in the two references mentioned in the previous paragraph were in studies not using electronic prescribing systems. As discussed in section 2.4, electronic prescribing systems have been shown to significantly reduce the rate of prescribing errors. Functionalities such as dosage range checks and pre-defined order sentences in electronic prescribing systems may be seen as system defences to reduce dose selection errors. However, this is refuted in the Westbrook et al. (2013) study of two electronic prescribing systems which demonstrated that wrong drug strength errors were among the most common system-related errors (22.5%). Alternative reasons for the low rate of incorrect dosing choice in the dissertation study may be related to the fact that only a limited number of medications with fixed and well-defined dosing schedules are prescribed in the GUIDE clinic. In addition, the clinicians in the GUIDE clinic are very familiar with prescribing these medications.

As previously mentioned, electronic prescribing systems have been shown to reduce prescribing error rates by introducing defence barriers against errors. This may explain the types of errors found in this dissertation study, and the distribution and proportion of these errors. The high rate of system-related errors, and those which may be seen to have minimal clinical significance, may be due to the fact that other error types are reduced by the electronic prescribing system. Therefore, the system-related errors make up a higher proportion of the total errors.

5.3.5 Prescription Types

The majority of errors in both the pre-intervention audit and post-intervention audit were as a result of copied/repeat prescriptions. This is reflected in the fact that the two main error types found, error types 2a (copied “dispensed” status) and 2b (copied “order comments” no longer valid/appropriate), are specifically related to copied/repeat prescriptions. Copying prescriptions from the previous entry, rather than entering a new original prescription, was the preferred method of prescribing for the majority of prescribers who responded to the questionnaire. Interestingly, many prescribers believed this method had less potential for error. As discussed in sections 5.3.1 and 5.3.2, error types 2a and 2b are strongly related to the system design. The fact that these errors were the most common, and yet prescribers generally

expected less errors with copied prescriptions, supports the concern by Westbrook et al. (2013) that system-related errors can be frequent in occurrence, but can have a low detection rate.

5.4 Conclusion

The discussion in this chapter has answered the research questions posed. The rate of prescribing errors for prescriptions generated by an electronic prescribing system was reduced following the training intervention. However, caution must be advised in interpreting this result and attributing the reduction wholly to the training intervention, given the potential confounding factors which shall be discussed in the next chapter. The types of prescribing errors occurring for prescriptions generated by the electronic prescribing system before and after the training intervention have been revealed and reviewed. A high rate of system-related errors was found and it is proposed that changes to the system design may eliminate the cause of the two main error types found (error types 2a (copied “dispensed” status) and 2b (copied “order comments” no longer valid/appropriate)). In the following and final chapter, conclusions are reached. The strengths and limitations of the study, possible confounding factors influencing the results, and areas for future work shall be identified.

Chapter 6. Conclusions

6.1 Introduction

This final chapter shall conclude the dissertation. This chapter discusses the strengths and limitations of the study, and the possible confounding factors influencing the results. Areas for future work are identified. Finally, the results are accounted for in light of the purpose of this dissertation outlined in Chapter 1.

6.2 Strengths of the Study

6.2.1 Strengths of the Research Methodology

In section 2.4 it was highlighted that electronic prescribing systems allow robust audit trails. In the case of this study, the ability to look back and remotely audit the electronic prescriptions was hugely advantageous. It allowed for easier validation of the data gathered, clarification of any unclear data collected and follow up of errors which occurred. This undoubtedly saved a lot of time for the researcher and ensured more accurate data were collected.

The staff and environment in the GUIDE clinic also facilitated the undertaking of this study. The staff generally have a positive attitude towards the electronic prescribing system, and towards research. The environment is one which has a fully integrated information technology system. Although processes to improve workflow have been previously undertaken in this environment, errors were still found. It was also noted in the questionnaire results, discussed in section 4.4, that the majority of prescribers who responded reported using the GUIDE EPR to prescribe medications for more than two years. This highlights that even in an environment where the majority of staff are well versed with and have a positive attitude towards electronic prescribing, errors and unintended mistakes can still occur. If errors can occur in this environment, and their prevalence reduced by a training intervention, this gives added support to the need for ongoing training with electronic prescribing systems in less well-defined environments. For example, in an environment where both manual and electronic systems are in use, or in an environment new to electronic prescribing, it could be expected that different errors or possibly greater rates of errors would be found. As proposed in section 3.6.3, audit and feedback benefits are most likely to transpire where baseline performance or compliance with the desired target or standard is low. The method of audit and feedback used in this research may be even more effective in an environment with higher predicted error rates than this study, due to a lower predicted baseline performance.

The research methods and exclusion criteria used in this study resulted in independent subjects for analysis of prescribing errors. The benefit of removing duplicate patients is that it

eliminates some potential confounding factors and bias. For example, if a patient had an error included in the study that was not resolved on the EPR, and the prescription was repeated during the audit period, the same error for the same patient would be accounted for again.

The training intervention allowed for both education of prescribers and for feedback of prescribing error types to prescribers. This was a strength of this method of training, as the literature commonly refers to the need to feedback details to prescribers of prescribing errors which occur. In section 2.3.3, it was emphasised that without a regular monitoring and feedback system, errors are not shared across the team and hospital-wide issues cannot be studied to try to develop error reduction strategies (Dean et al., 2002b). This study fulfils the recommendation from Velo and Minuz (2009) that prescribers are informed of errors that have been made in their environment, and of analysis conclusions. The results of this study support the suggestion by Ivers et al. (2012) that while audit and feedback may result only in small improvements, these are potentially important improvements in professional practice.

6.2.2 Strengths of the Research Outcomes

An important strength of this study is that it bridges the gap in the literature that was a lack of studies giving evidence to support the need for training and education for electronic prescribing. The study provides evidence that a training intervention, coupled with an audit cycle, may reduce the rates of prescribing errors within an electronic prescribing system. This study supports the importance of ongoing training by showing that this training intervention may improve prescribers' understanding of and interaction with an electronic prescribing system.

As flagged in section 5.3.5, the high frequency of system-related errors found in this study supports the concern of Westbrook et al. (2013) that system-related errors can be frequent in occurrence. Prior to the study, although anecdotally pharmacists reported that the errors found most commonly in this study were occurring frequently, there was no data or error reports to support these claims. A strength of this study is that it provides information on the types of prescribing errors occurring in the GUIDE clinic, and the frequency rates for the different error types that was not previously available.

Although many of the error types found in this study may not be seen as particularly clinically significant to patient outcomes, their reduction does result in improved workflow, time saving, and more accurate prescribing. This is a benefit gained by the GUIDE clinic as a result of the intervention undertaken in this study.

6.3 Limitations and Confounding Factors

Although a positive outcome on the rate of prescribing errors was found overall, certain limitations exist in this study which must be acknowledged. In addition, confounding factors which may have influenced the results, other than the training intervention, must be taken into account. The limitations should be considered when applying the results of this study to practice or research.

6.3.1 Limitations of the Study Setting

This study involved senior clinicians prescribing medications. These clinicians are all specialists in the area of genito urinary medicine and infectious diseases and therefore largely familiar with the medications being prescribed. This may limit the applicability of these results to a more general prescribing population. It has been highlighted that junior prescribers are expected to perform a significant prescribing role in hospitals and are responsible for writing most prescriptions (Kamarudin et al., 2013, Velo and Minuz, 2009). Kamarudin et al. (2013) also outline that junior prescribers appear most susceptible to prescribing errors. Therefore, the error rates found in this study may be considered unique to the particular study setting. Much of the available literature reviewed involved the study of junior doctors, such as the systematic review by Ross et al. (2009) discussed in section 2.3.3. It is difficult to draw firm conclusions based on comparisons between this dissertation study and the studies in the literature, given the different clinician types and unique environment in the GUIDE clinic.

The medications included in this study were oral and topical medications only, as these are the medications dispensed by the GUIDE pharmacy. In an inpatient setting, patients would also be prescribed parenteral drugs such as those by the intravenous, intramuscular and subcutaneous route. According to the American Institute of Medicine, intravenous medicines are associated with the highest percentage of medication errors (Aspden et al., 2007). High-risk medications such as anticoagulants, insulin, opioids and chemotherapy were also not included in this review (Aspden et al., 2007). Furthermore, only a limited number of medications, which are used specifically for genito urinary medicine and infectious diseases, are prescribed in the GUIDE clinic. Therefore, prescribers are more likely to be familiar with the medications being prescribed as many patients are on the same medications. In a mixed patient cohort, where clinicians are prescribing for multiple comorbidities, there is an increased level of complexity. Given all of the above, the rates and types of error found in this review may not be applicable to other settings, such as hospital inpatients. However, as eluded to in section 6.2.1 this could be seen as a strength. If errors can be found and reduced by this training method in a setting using a limited number of oral and topical medications prescribed by

experienced clinicians, it could be anticipated that there may be a greater effect of a similar training intervention on reducing errors in a setting which is considered to be more error prone.

6.3.2 Limitations of the Study Results

There were statistically significantly more consultant prescribers in the pre-intervention audit than the post-intervention audit and significantly more registrar prescribers in the post-intervention audit than the pre-intervention audit, as outlined in section 4.3.1. Therefore, the study setting was not the same for both audits. The difference in error rates before and after the intervention may have been related to the difference in prescribers prescribing medications in each audit, rather than as a result of the training intervention. This is a potential confounding factor that must be considered when interpreting the effect of the training intervention.

As discussed in section 5.3.4, error type 4a (related to pre-pack prescriptions) was statistically significantly reduced following the training intervention. However, this error type is more likely to occur in the STI clinic type, and there were statistically less patients and medications prescribed in the STI clinic type in the post-intervention audit. This change in clinic type demographics is an example of a confounding factor which is much more likely to have impacted on the results for error type 4a than the training intervention, particularly given this error type was not discussed in detail in the training intervention.

There was only one post-intervention audit carried out due to time restrictions for this study. Therefore, the effect of the training intervention over time was not investigated. Given that the post-intervention audit was held two weeks after the intervention, there is a risk that the intervention was too fresh in the minds of prescribers to reflect a sustained impact. While the intervention may have had an impact in the immediate time period after its delivery, there is a risk that with time prescribers may revert to old prescribing habits and errors may be reintroduced. Ideally, further time points would be included in the study to analyse the effect of time on the intervention's impact.

The clinical significance of the various error types was not assigned in this study. This limits the interpretation of the importance of the error reductions found in this study. In addition, much of the literature focuses on the impact of errors on the patient. Since this was not addressed in this study, this research cannot be used to contribute to the evidence relating to patient specific outcomes and the effect of training.

6.4 Future Work and Research

6.4.1 Use of the Study Outcomes

As mentioned previously, electronic prescribing is likely to be rolled out in St James's Hospital, and indeed other Irish hospitals, in the next number of years. The results of this study could be used to inform the planning for training interventions to be delivered as part of ongoing electronic prescribing maintenance. The study stands to inform those managing electronic prescribing system projects that, despite initial training, errors can still occur in the system and must be addressed. The need for resources to be allocated to ongoing training could be supported by the results of this study. In section 2.5.2, the potential resources to be considered for electronic prescribing training were discussed. The Australian Commission on Safety and Quality in Health Care (2012) recommend that hospitals consider having two full-time trainers for ongoing training after implementing electronic prescribing. However, as mentioned previously, it is noted that the hospital size or number of staff using the electronic prescribing system is not provided for reference. Creating posts such as these in a hospital generally requires a business case to be developed in order to allocate and fund such resources. In order to justify the need for resources, the results of this study could be used to highlight the impact training resources may have. Further audit cycles giving additional evidence to training interventions may also stand to support the need for resource allocation.

The data collection tool designed in this study could be used for periodic audits of errors in the GUIDE clinic, and indeed it could be amended for any electronic prescribing system. This data collection tool could be used to analyse errors independent of the need to perform a training intervention. For example, the initial impact of introducing an electronic prescribing system could be analysed by performing an audit to review prescribing errors before and after the system is introduced, using this data collection tool. In the future it would be useful if this could be developed further and an error reporting system could be built into or linked to the electronic prescribing system. This would help with future audits of this type and provide ongoing information on error rates and types, rather than relying on periodic audits which can be resource intensive. Similarly, the methodologies used in this study to review prescribers' interactions with an electronic prescribing system, such as the questionnaire and error analysis tools, could be utilised at the point of tendering and testing of a new electronic prescribing system. For example, test prescribing environments could be employed for clinicians to trial a new system and errors generated could be analysed using the methods from this study.

As flagged in section 5.3, there was a high frequency of system-related errors found in this study. Suggestions as to how the electronic prescribing system in the GUIDE clinic could be amended to eliminate some of these system-related errors were made in sections 5.3.1 and

5.3.2. Going forward, these suggestions will be fed back to the software providers in order to address the main error types found in this study.

6.4.2 Future Areas of Research

In St. James's Hospital a second electronic prescribing system, IntelliVue Clinical Information Portfolio® (ICIP), is in use in the intensive care units (ICUs). This study methodology could be carried out in the ICU setting using the ICIP® system to review the impact of a training intervention in a different study setting. This study setting would differ to the GUIDE setting in several ways. Since the ICU electronic prescribing system is used for inpatient prescriptions, the same dispensing procedures as those in the GUIDE pharmacy are not in place. In addition, ICU patients are generally more complex patients and prescribed parenteral medications. As mentioned in section 6.3.1, these medications are generally associated with a greater incidence of medication errors. It would be interesting to compare error rates and types between the GUIDE electronic prescribing system and the ICU system.

It would be useful to adopt the training methods used in this study and analyse their impact when an electronic prescribing system is put in place for general hospital inpatients. As alluded to previously, the complexity of the medications prescribed to inpatients is greater than that in the current study setting in GUIDE. Medications which were not included in this research, which would be particularly interesting to study in relation to an electronic prescribing system, include medications with tapering doses, warfarin (which often requires different doses on different days depending on results from patient's blood tests) and intravenous infusions which require infusion rate adjustments. Furthermore, a variety of prescribers will be interacting with an electronic prescribing system in the general inpatient wards, including junior doctors who were not accounted for in this study. Research in the general hospital setting may bridge some of the limitations about the GUIDE specific study setting discussed in section 6.3.1.

This research has focused on a group of clinicians prescribing medications. However, the methods used in this study which address users' interactions with an electronic system could also be adopted for studies of similar systems with reported errors. By applying the research methods used in this study, the effect of training on error rates for various tasks involving healthcare information technology could be reviewed. Other tasks involving medications that could be studied using a similar audit and feedback cycle with a training intervention are errors of dispensing and administration of medications. Errors in these tasks also pose a threat to patient safety. The introduction of electronic systems to aid these tasks will, like electronic prescribing, introduce significant workflow changes which will require training for users. Other healthcare information technology systems not involving medications could also utilise these

methods. For example, error rates in a hospital electronic laboratory system could be reviewed before and after a training intervention.

It is noted that the questionnaire revealed that the majority of prescribers' preferred method of training is one-to-one training with the lead clinician for the GUIDE EPR. For practical and resource reasons, one-to-one training has not been reviewed in this study. A similar study to this dissertation study could be carried out, comprising two groups and comparing the effect of one-to-one training versus classroom-based training on prescribing errors. This could be useful to reveal which method has a greater effect on reducing errors. One-to-one ongoing training is resource intensive and, without evidence to show a significant benefit over classroom-based training, it may be difficult to justify the additional resources required for this. Therefore, a study to test and compare this training method may be beneficial.

6.5 Personal Reflection

The methods used in this study worked well to achieve the research aims and objectives. In particular, the ability for pharmacists to capture data prospectively as part of their routine work was very helpful both from an efficiency and accuracy point of view. It was easier to recall details of the errors found by recording the data at the time of detection and reduced the need to look back for data at a later time.

Unfortunately, the confounding factor of different prescriber type distributions in the pre-intervention and post-intervention audits limits the ability to make firm conclusions regarding the impact of the training intervention on prescribing errors. If this confounding factor were removed and a more targeted approach was taken, reviewing the same prescribers at similar distributions in both the pre-intervention and post-intervention audits, the evidence for the effect of the training intervention would be stronger.

As electronic prescribing is a growing area there were some challenges presented when searching the literature for available evidence relating specifically to training. The lack of evidence for specific training approaches for electronic prescribing also made it difficult to decide on the best approach to use for the training intervention in this study. In the future, it would be beneficial if there were more studies of this kind carried out to compare different types of training interventions and approaches.

One of the key motivations for this research which was highlighted in Chapter 1, was the need to plan well for the implementation of an electronic prescribing system, and in particular for the training and education needs. Anticipating the challenges presented by the introduction of an electronic prescribing system is important. This study has shown that even in a setting where electronic prescribing is well established, errors can still occur. This serves to inform those

planning for electronic prescribing of the great challenges faced in relation to education and training for users of these systems. To facilitate a smooth transition to electronic prescribing, and to ensure the appropriate ongoing use of the system, it is clear that resources will be required. A training intervention such as that undertaken in this study appears to be beneficial. However, a once off training intervention alone is unlikely to be sufficient to sustain safe, accurate and efficient use of an electronic prescribing system. Training interventions tailored to different users and tasks will be required for future roll outs of electronic prescribing systems, and these interventions will need to be ongoing throughout the life time of such a system.

6.6 Conclusion

The aim of the study was to assess the effect of a training intervention on the prevalence and types of prescribing errors for prescriptions generated by an electronic prescribing system in a genito urinary medicine and infectious diseases outpatient clinic. The study has found that following the training intervention delivered, the prevalence of prescribing errors was significantly reduced. The types of prescribing errors found before the training intervention were broadly similar to those found after the training intervention, but the rate of certain errors was different following the intervention. A large proportion of the errors found in both audits were system-related errors. The review of the literature, the research methods used, and the analysis of findings has allowed the seven research objectives set out in section 3.4 to be met.

The study contributes to bridging the gap in the literature that was identified due to a lack of studies providing evidence to support the need for training and education for electronic prescribing. However, certain limitations exist in this study which must be considered when interpreting the results and drawing conclusions. In particular, it is noted that there was a different distribution of prescriber types in the two audits. Further research without this confounding factor may allow firmer conclusions to be made regarding the impact of the training intervention on prescribing errors. Despite its limitations, the study provides some evidence that a training intervention, coupled with an audit cycle, may reduce the rates of prescribing errors within an electronic prescribing system. In order to strengthen the case for resources for staff training for an electronic prescribing system, it is hoped that the results of this study can be used to highlight the importance of ongoing training for users of an electronic prescribing system, and to plan for the training interventions to be delivered as part of ongoing system maintenance.

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Appendices

Appendix A: PRISMA Checklist (Moher et al., 2009)

Table 1. Checklist of Items to Include When Reporting a Systematic Review or Meta-Analysis

Section/Topic	Item #	Checklist Item
TITLE		
Title	1	Identify the report as a systematic review, meta-analysis, or both.
ABSTRACT		
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.
INTRODUCTION		
Rationale	3	Describe the rationale for the review in the context of what is already known.
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).
METHODS		
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.
RESULTS		
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome-level assessment (see Item 12).
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group and (b) effect estimates and confidence intervals, ideally with a forest plot.
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).
DISCUSSION		
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., health care providers, users, and policy makers).
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review level (e.g., incomplete retrieval of identified research, reporting bias).
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.
FUNDING		
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.

Appendix B: Prescribing Error Situations as per the Dean et al. (2000) Definition

As outlined in section 2.3.2, accompanying their definition of a prescribing error, Dean et al. (2000) have listed situations that should and should not be included as prescribing errors, as well as those situations that may be considered prescribing errors depending on the individual clinical situation. These situations are listed in Table 7.1, Table 7.2 and Table 7.3 below.

Table 7.1: Situations that should be included as prescribing errors as per the Dean et al. (2000) definition of a prescribing error

Errors in decision making
<i>Prescription inappropriate for the patient concerned</i>
1. Prescribing a drug for a patient for whom, as a result of a co-existing clinical condition, that drug is contraindicated
2. Prescribing a drug to which the patient has a documented clinically significant allergy
3. Not taking into account a potentially significant drug interaction
4. Prescribing a drug in a dose that, according to British National Formulary or data sheet recommendations, is inappropriate for the patient's renal function
5. Prescribing a drug in a dose below that recommended for the patient's clinical condition
6. Prescribing a drug with a narrow therapeutic index, in a dose predicted to give serum levels significantly above the desired therapeutic range
7. Writing a prescription for a drug with a narrow therapeutic range in a dose predicted to give serum levels significantly below the desired therapeutic range
8. Not altering the dose following steady state serum levels significantly outside the therapeutic range
9. Continuing a drug in the event of a clinically significant adverse drug reaction
10. Prescribing two drugs for the same indication when only one of the drugs is necessary
11. Prescribing a drug for which there is no indication for that patient
<i>Pharmaceutical issues</i>
12. Prescribing a drug to be given by intravenous infusion in a diluent that is incompatible with the drug prescribed
13. Prescribing a drug to be infused via an intravenous peripheral line, in a concentration greater than that recommended for peripheral administration

Table 7.1 [continued]: Situations that should be included as prescribing errors as per the Dean et al. (2000) definition of a prescribing error

Errors in prescription writing
<i>Failure to communicate essential information</i>
14. Prescribing a drug, dose or route that is not that intended
15. Writing illegibly
16. Writing a drug's name using abbreviations or other non-standard nomenclature
17. Writing an ambiguous medication order
18. Prescribing "one tablet" of a drug that is available in more than one strength of tablet
19. Omission of the route of administration for a drug that can be given by more than one route
20. Prescribing a drug to be given by intermittent intravenous infusion, without specifying the duration over which it is to be infused
21. Omission of the prescriber's signature
<i>Transcription errors</i>
22. On admission to hospital, unintentionally not prescribing a drug that the patient was taking prior to their admission
23. Continuing a GP's prescribing error when writing a patient's drug chart on admission to hospital
24. Transcribing a medication order incorrectly when rewriting a patient's drug chart
25. Writing "milligrams" when "micrograms" was intended
26. Writing a prescription for discharge medication that unintentionally deviates from the medication prescribed on the inpatient drug chart
27. On admission to hospital, writing a medication order that unintentionally deviates from the patient's pre-admission prescription

Table 7.2: Situations that may be considered prescribing errors (depending on the individual clinical situation) as per the Dean et al. (2000) definition of a prescribing error

1. Prescribing a drug in a dose above the maximum dose recommended in the British National Formulary or data sheet
2. Misspelling a drug name
3. Prescribing a dose that cannot readily be administered using the dosage forms available
4. Prescribing a dose regimen (dose/frequency) that is not that recommended for the formulation prescribed
5. Continuing a prescription for a longer duration than necessary
6. Prescribing a drug that should be given at specific times in relation to meals without specifying this information on the prescription
7. Unintentionally not prescribing a drug for a clinical condition for which medication is indicated

Table 7.3: Situations that should not be included as prescribing errors as per the Dean et al. (2000) definition of a prescribing error

1. Prescribing by brand name (as opposed to generic name)
2. Prescribing a drug without informing the patient of its uses and potential side effects
3. Prescribing a drug for which there is no evidence of efficacy, because the patient wishes it
4. Prescribing for a child a drug that has no product license for use in children
5. Prescribing a drug that is not in the hospital formulary
6. Prescribing contrary to hospital treatment guidelines
7. Prescribing contrary to national treatment guidelines
8. Prescribing for an indication that is not a drug's product license

Appendix C: National Prescribing Centre (2012): Single Competency Framework for All Prescribers [UK]

Domain A: The consultation	
Competency 1	<p>Knowledge</p> <p>Has up-to-date clinical, pharmacological and pharmaceutical knowledge relevant to own area of practice.</p>
Competency 2	<p>Options</p> <p>Makes or reviews a diagnosis, generates management options for the patient and follows up management.</p>
Competency 3	<p>Shared decision making (with parents, care-givers or advocates where appropriate)</p> <p>Establishes a relationship based on trust and mutual respect.</p> <p>Recognises patients as partners in the consultation.</p>
Domain B: Prescribing Effectively	
Competency 4	<p>Safe</p> <p>Is aware of own limitations. Does not compromise patient safety.</p>
Competency 5	<p>Professional</p> <p>Ensures prescribing practice is consistent with scope of practice, organisational, professional and regulatory standards, guidance and codes of conduct.</p>
Competency 6	<p>Always improving</p> <p>Actively participates in the review and development of prescribing practice to optimise patient outcomes.</p>
Domain C: Prescribing in context	
Competency 7	<p>The healthcare system</p> <p>Understands and works within local and national policies, processes and systems that impact on prescribing practice. Sees how own prescribing impacts on the wider healthcare community.</p>
Competency 8	<p>Information</p> <p>Knows how to access relevant information. Can use and apply information in practice.</p>
Competency 9	<p>Self and others</p> <p>Works in partnership with colleagues for the benefit of patients. Is self-aware and confident in own ability as a prescriber.</p>

Appendix D: National Prescribing Service (2012): Prescribing Competencies Framework - Seven Competency Areas [Australia]

Competency Area 1	Understands the person and their clinical needs.
Competency Area 2	Understands the treatment options and how they support the person's clinical needs.
Competency Area 3	Works in partnership with the person to develop and implement a treatment plan.
Competency Area 4	Communicates the treatment plan clearly to other health professionals.
Competency Area 5	Monitors and reviews the person's response to treatment.
Horizontal Competency Area H1	Practices professionally.
Horizontal Competency Area H2	Communicates and collaborates effectively with the person and other health professionals.

TRINITY COLLEGE DUBLIN

INFORMATION SHEET FOR PROSPECTIVE PARTICIPANTS - PHARMACY STAFF

LEAD RESEARCHER: Fionnuala Nevin

BACKGROUND OF RESEARCH: This research study aims to investigate the effect of training of users of an electronic prescribing system on the quality of prescriptions generated using the system.

PROCEDURES OF THIS STUDY: The study will involve a review of prescriptions generated using the electronic prescribing system in the GUIDE clinic before and after a training education session with prescribers. The data to be collected will focus on prescriptions generated by GUIDE prescribers using the electronic patient record (EPR) and any associated errors and quality issues. It is requested that GUIDE pharmacy staff will collect the data during routine screening and dispensing of prescriptions. Following the training education session, further data will be collected by the same means in order to compare the prescriptions generated pre-intervention and post-intervention.

PUBLICATION: The primary purpose of this research is to fulfil the research dissertation requirements for the MSc in Health Informatics, Trinity College Dublin. Individual results will be completely anonymised and aggregated. The results will be published in the dissertation and may be presented in the future at appropriate conferences and/or in published journal articles.

Please note:

- Participants have been selected to include all those screening and dispensing prescriptions in the GUIDE pharmacy.
- Participation in this study is completely voluntary.
- Participants may refuse to take part in data collection and may withdraw at any time without penalty.
- Participation is fully anonymous and no personal details will be recorded. Any data collected will be treated with full confidentiality.
- In the extremely unlikely event that any illicit activities are made known, these will be reported to appropriate authorities.
- No conflicts of interest have been found.

Appendix F: Informed Consent Form – Pharmacy Staff

TRINITY COLLEGE DUBLIN INFORMED CONSENT FORM – PHARMACY STAFF

LEAD RESEARCHER: Fionnuala Nevin

BACKGROUND OF RESEARCH: This research study aims to investigate the effect of training of users of an electronic prescribing system on the quality of prescriptions generated using the system.

PROCEDURES OF THIS STUDY: The study will involve a review of prescriptions generated using the electronic prescribing system in the GUIDE clinic before and after a training education session with prescribers. The data to be collected will focus on prescriptions generated by GUIDE prescribers using the electronic patient record (EPR) and any associated errors and quality issues. It is requested that GUIDE pharmacy staff will collect the data during routine screening and dispensing of prescriptions. Following the training education session, further data will be collected by the same means in order to compare the prescriptions generated pre-intervention and post-intervention.

PUBLICATION: The primary purpose of this research is to fulfil the research dissertation requirements for the MSc in Health Informatics, Trinity College Dublin. Individual results will be completely anonymised and aggregated. The results will be published in the dissertation and may be presented in the future at appropriate conferences and/or in published journal articles.

DECLARATION:

- I am 18 years or older and am competent to provide consent.
- I have read and understood a document providing information about this research. Any questions I had have been answered to my satisfaction.
- I agree that data collected by me is used for scientific purposes and may be published in scientific publications in a way that does not reveal my identity.
- I understand that in the extremely unlikely event that any illicit activities are made known, these will be reported to appropriate authorities.
- I freely and voluntarily agree to be part of this research study, though without prejudice to my legal and ethical rights.
- I understand that I may refuse to take part and may withdraw at any time without penalty.
- I understand that my participation is fully anonymous and no personal details about me will be recorded.
- I have received a copy of this agreement.

PARTICIPANT'S NAME:

PARTICIPANT'S SIGNATURE:

Date:

Statement of investigator's responsibility: I have explained the nature and purpose of this research study, the procedures to be undertaken and any risks that may be involved. I have offered to answer any questions and fully answered such questions. I believe that the participant understands my explanation and has freely given informed consent.

RESEARCHERS CONTACT DETAILS: Fionnuala Nevin (email: fnevin@stjames.ie, telephone: 086-1945281)

INVESTIGATOR'S SIGNATURE:

Date:

Appendix G: GUIDE Prescription Audit Data Collection Sheets

GUIDE Prescription Audit Data Collection Sheets

Instructions for collecting the GUIDE prescription data using the data collection sheets:

- Please fill out one line per patient.
- Please indicate the number of medications prescribed to be dispensed by the GUIDE pharmacy.
 - Do not include vaccinations or other medications administered by the clinician.
 - The exception to this is prepack medications which are entered in error as medications to be dispensed by the pharmacy.
- Please indicate the number of medications for which an error was found. If the same error was found for each medication prescribed, please count for each medication (i.e. if 3 medications prescribed and 3 contain the same error please enter 3 into the column entitled “How many medications contained an error?”).
- If an error is found, please complete the columns shaded in grey.
- If no error is found, please do not complete the columns shaded in grey.
- If any errors from the list of errors in table 1 applies to the prescription, please enter the numerical code(s) (e.g. 1a, 2b etc.) for the error into the applicable column.
- If more than one error is found, please enter all error codes that apply.
- If an error other than those listed in table 1 is found, please indicate and give details in the applicable column.
- For the question asking “For repeat (copied) prescriptions, has this error happened more than once for this prescription?” please enter non applicable (N/A) if the error code 2a is found.
- If the error was rectified on the system, please indicate if this was rectified by pharmacy staff (enter P) or prescribing clinician (enter C).

For further information, please contact the Lead Researcher:

Fionnuala Nevin

Email: fnevin@stjames.ie

Telephone: 0861945281 or 01-4284119

TABLE 1: LIST OF POTENTIAL ERRORS		
1.	Error in prescription field	Example
1a	Incorrect drug	Kivexa® prescribed instead of Triumeq®
1b	Incorrect dose (including incorrect strength/volume OR incorrect unit)	
1c	Incorrect form	
1d	Incorrect route	
1e	Incorrect frequency/administration details – includes “as directed”/ “as required”	
2.	Error associated with copying prescription	
2a	Previous prescription copied/repeated but “dispensed status” not amended. The prescription indicates that the prescription is “dispensed”.	
2b	Details in “order comments” or “special instructions” field repeated from previous prescription that are no longer valid/appropriate (other than “dispensed status”)	
3.	Error in receipt of task by GUIDE pharmacy	
3a	Patient waiting for medications but no order received by GUIDE pharmacy due to omission of prescription	
3b	Patient waiting for medications but no order received by GUIDE pharmacy due to omission of task creation (for example medication was prescribed as part of the incorrect episode)	
3c	GUIDE pharmacy task generated but no note and no prescription attached	
4.	Error relating to pre-pack medicines	
4a	Pre-pack prescription selected but the prescription is intended to be dispensed in the GUIDE pharmacy.	
4b	Task received in the GUIDE pharmacy to dispense prescription but the prescription was already dispensed as a pre-pack by the prescriber.	
5.	Clinical error	
5a	Inappropriate prescription due to drug-drug interaction	
5b	Inappropriate prescription due to patient’s allergy status	
5c	Inappropriate dose due to patient’s renal function	
5d	Inappropriate prescription for other clinical reason – please give details in following column	

TRINITY COLLEGE DUBLIN

INFORMATION SHEET FOR PROSPECTIVE PARTICIPANTS - PRESCRIBERS

LEAD RESEARCHER: Fionnuala Nevin

BACKGROUND OF RESEARCH: This research study aims to investigate the effect of training of users of an electronic prescribing system on the quality of prescriptions generated using the system.

PROCEDURES OF THIS STUDY: The study will involve a review of prescriptions generated using the electronic prescribing system in the GUIDE clinic before and after a training education session with prescribers. This questionnaire has been developed to gain some insight into the interaction of prescribers with the system.

PUBLICATION: The primary purpose of this research is to fulfil the research dissertation requirements for the MSc in Health Informatics, Trinity College Dublin. Individual results will be completely anonymised and aggregated.

Please note:

- Participants have been selected to include all those prescribing electronically in the GUIDE clinic.
- Participation in this study is completely voluntary.
- Participants may refuse to answer any question and may withdraw at any time without penalty.
- Participation is fully anonymous and no personal details will be recorded. Any data collected will be treated with full confidentiality.
- In the extremely unlikely event that any illicit activities are made known, these will be reported to appropriate authorities.
- No conflicts of interest have been found.

Appendix I: Informed Consent Form – Prescribers

TRINITY COLLEGE DUBLIN INFORMED CONSENT FORM – PRESCRIBERS

LEAD RESEARCHER: Fionnuala Nevin

BACKGROUND OF RESEARCH: This research study aims to investigate the effect of training of users of an electronic prescribing system on the quality of prescriptions generated using the system.

PROCEDURES OF THIS STUDY: The study will involve a review of prescriptions generated using the electronic prescribing system in the GUIDE clinic before and after a training education session with prescribers. This questionnaire has been developed to gain some insight into the interaction of prescribers with the system.

PUBLICATION: The primary purpose of this research is to fulfil the research dissertation requirements for the MSc in Health Informatics, Trinity College Dublin. Individual results will be completely anonymised and aggregated.

DECLARATION:

- I am 18 years or older and am competent to provide consent.
- I have read and understood a document providing information about this research. Any questions I had have been answered to my satisfaction.
- I agree that my data is used for scientific purposes and may be published in scientific publications in a way that does not reveal my identity.
- I understand that in the extremely unlikely event that any illicit activities are made known, these will be reported to appropriate authorities.
- I freely and voluntarily agree to be part of this research study, though without prejudice to my legal and ethical rights.
- I understand that I may refuse to answer any question and withdraw at any time without penalty.
- I understand that my participation is fully anonymous and no personal details about me will be recorded.
- I understand that if I or anyone in my family has a history of epilepsy then I am proceeding at my own risk.
- I have received a copy of this agreement.

PARTICIPANT'S NAME:

PARTICIPANT'S SIGNATURE:

Date:

Statement of investigator's responsibility: I have explained the nature and purpose of this research study, the procedures to be undertaken and any risks that may be involved. I have offered to answer any questions and fully answered such questions. I believe that the participant understands my explanation and has freely given informed consent.

RESEARCHERS CONTACT DETAILS: Fionnuala Nevin (email: fnevin@stjames.ie, telephone: 086-1945281)

INVESTIGATOR'S SIGNATURE:

Date:

Appendix J: Questionnaire

This questionnaire was distributed using Qualtrics online survey software. Below is a copy of the questions asked.

GUIDE ELECTRONIC PRESCRIBING QUESTIONNAIRE

- *Please do not name third parties in any open text field of the questionnaire. Any such replies will be anonymised.*
- *Each question is optional. Feel free to omit a response to any question; however, the researcher would be grateful if all questions are responded to.*

1. Please state your job position:

- Consultant
- GUM Specialist
- Registrar
- GP Trainee
- Nurse Prescriber
- Other

2. How long have you personally been using the Cerner® EPR in St James's Hospital to prescribe medications?

- Less than 6 months
- 6 months to 1 year
- More than 1 year but less than 2 years
- 2 years or more

3. Have you previously used an electronic prescribing system prior to working in the GUIDE clinic?

- Yes
- No

If yes, which electronic prescribing system did you use?

- Cerner® electronic prescribing system
- Other

Each question is optional. Feel free to omit a response to any question; however, the researcher would be grateful if all questions are responded to.

4. When did you last receive training* on how to use the Cerner® electronic prescribing system?

- Less than 3 months ago
- 3 to 6 months ago
- More than 6 months ago
- No training received

*Examples of training may include one-to-one training sessions with Dr. Grainne Courtney, classroom training during a lunchtime education session, reading the EPR training manual, attending an IMS led EPR training session, or informal training from another staff member.

5. Which of the following electronic prescribing training interventions have you undertaken in the last year (please tick all that apply):

- One-to-one training session with Dr. Grainne Courtney lasting less than 20 minutes
- One-to-one training session with Dr. Grainne Courtney lasting over 20 minutes
- Classroom training during a lunchtime education session
- Read the EPR training manual
- Attended an IMS led EPR training session
- Informal training from another staff member
- No training received in the last year
- Other (please give details): _____

6. Of the training interventions which you received, which did you find the most beneficial for the purpose of using the electronic prescribing function in the Cerner® EPR?

- One-to-one training session with Dr. Grainne Courtney lasting less than 20 minutes
- One-to-one training session with Dr. Grainne Courtney lasting over 20 minutes
- Classroom training during a lunchtime education session
- Reading the EPR training manual
- Attending the IMS led EPR training session
- Informal training from another staff member
- No training received in the last year
- Other (please give details): _____

Each question is optional. Feel free to omit a response to any question; however, the researcher would be grateful if all questions are responded to.

7. Overall, do you prefer prescribing medications on paper using handwriting or on the Cerner® EPR electronically?

- Prefer prescribing on paper using handwriting
- Prefer prescribing on the Cerner® EPR electronically
- Do not have a preference

Please give the main reason for your choice above: _____

8. Do you have a favourites folder from which you select commonly prescribe medicines?

- Yes
- No

9. Do you know how to add order sentences to your favourites folder?

- Yes
- No

10. On average, how easy is it to find a medicine that you are looking for – other than those in a favourites folder?

- Very Difficult
- Difficult
- Somewhat Difficult
- Neutral
- Somewhat Easy
- Easy
- Very Easy

11. Do you know how to prescribe a medicine that you cannot find in the drug catalogue – i.e. you cannot find it when you search for it?

- Yes
- No

Each question is optional. Feel free to omit a response to any question; however, the researcher would be grateful if all questions are responded to.

12. For patients who require a repeat prescription of their previously prescribed medications, do you prefer to copy prescriptions from the previous entry or to enter them as original prescriptions?

- Copy the previous prescription
- Enter them as an original prescription

Please give the reason(s) for your answer above:

- Quicker
- Less potential for error
- Less familiar with other method
- Other (please give details): _____

13. Are you aware of the legal requirement to remove the word "dispensed" from the "dispensing status" field of copied prescriptions?

- Yes
- No

14. What, if any, is the main improvement you would like to see in the current Cerner® EPR prescribing function? (please give details)

15. Please enter any additional comments you may have regarding electronic prescribing in the GUIDE clinic or this research below:

Appendix K: St James's Hospital Risk and Legal Department Approval

2015/114

ST. JAMES'S HOSPITAL

PROPOSED INTERNAL AUDIT / RESEARCH ACTIVITY

HOSPITAL APPROVAL FORM

PREAMBLE

This form should be completed in respect of all proposed internal research / audit projects and Submitted to the Legal/Insurance Manager for approval prior to the research being undertaken. Internal audit/research means research that does not involve patient contact, but does involve the use of hospital information, or information systems.

The research may proceed subject to approval being forthcoming from the relevant Department/s, and where hospital resource usage applies, that related requirements can be met from within the relevant departmental/line item budgetary allocation. Such research is also governed by ethical and data protection principles.

1. TYPE OF RESEARCH ACTIVITY (please tick)

- Clinical Research
- Non-Clinical Research
- Clinical Audit
- Non-Clinical Audit

2. PROJECT TITLE (PRINT)

An investigation of the effect of a prescriber training
intervention on prescription errors & the quality of prescriptions
generated by an electronic prescribing system.

(As part fulfilment of masters in Health Informatics, Trinity College Dublin -)
Research Dissertation

3. BRIEF DESCRIPTION OF THE PROPOSED RESEARCH/AUDIT ACTIVITY:

Using GUIDE EPR pharmacy staff will measure the number of prescriptions errors & monitor the quality of prescriptions for a two week period. A clinician will be observed interacting with EPR to prescribe medications. Clinicians in the GUIDE clinic will be surveyed via a questionnaire to get feedback on their interaction with the system. A training intervention will be designed & delivered at a Monday GUIDE education session. Prescription errors & quality of prescriptions will be remeasured for a two week period post training intervention. The results pre & post intervention will be analysed & compared

➤ **Liaison Person and Contact Number/Bleep** Fionnuala Nevin ext 2553

Please Note: Where Charts are required to be pulled by chart room staff, a list of MRNs should be furnished to the Medical Records Officer along with a copy of this form once approved. Chart pulling arrangements should be agreed with the Medical Records Officer. Removal of charts or other patient related information from St James's Hospital premises is forbidden.

7. FINANCIAL ARRANGEMENTS

Will there be funding available for this research activity?

YES NO

If YES, Please state

Amount and source of funding Not required

8. DATA CONTROL AND PROTECTION

In what form will data be collected and held?

Data will be collected initially using paper forms and thereafter entered into Microsoft Excel + Word.

How long is collected data intended to be retained?

up to 1 year

What physical or computerised protections will be in place in relation to data collected?

Patient identifiers will be anonymised using numerical values to be assigned (eg. patient 1, 2, 3, 4). An Excel datasheet containing patient identifiers + codes shall be stored in a restricted access folder in the pharmacy hospital U drive + shall not be stored/transferred anywhere else. Access only granted to Principal Investigator hospital login.

Will a memory stick or removable memory storage device be used?

Memory stick may be used to remove anonymised data + analyse off site.

Will collected data be transferred outside of the Hospital computer system?

Only anonymised data.

If Yes:

What transfers are envisaged?

Transfer to personal laptop for analysis of anonymised data

What agreements are in place/planned?

No patient identifiers will be on the data transferred outside hospital.
No clinician identifiers will be on the data transferred outside hospital.

All data will be anonymised. Eg. number, type + frequency of errors. + Details of questionnaire feedback not linked to individual person surveyed

8. DESTRUCTION / LIFETIME OF DATA COLLECTED

Who is the Data Controller for the research/audit?

Fionnuala Nevin

Who will be responsible for the safekeeping and eventual destruction of all created records both manual and computerised when the research is completed?

Fionnuala Nevin

On completion of the research activity a brief summary of the findings and a copy of any publication arising from it should be sent to the Operations Manager. Confirmation of the destruction of any secondary records collected as part of the research activity should also be provided.

9. DECLARATION

I confirm that the information provided herein is accurate and discloses the complete resource implications, grants/funding provisions and data protection provisions applicable to the specified proposed research activity.

Yak (Fionnuala Nevin)

Applicant and/or Principal Investigator

8/12/15

Date

10. APPROVAL ON BEHALF OF ST JAMES'S HOSPITAL

Muiréann O Brain

Legal/Insurance Manager

8 December 2015

Date

Appendix L: SJH/AMNCH Research Ethics Committee Waiver

THIS NOTEPAPER MUST NOT BE USED FOR
PRESCRIPTIONS OR INVOICING PURPOSES



**THE ADELAIDE & MEATH
HOSPITAL, DUBLIN**
INCORPORATING
THE NATIONAL CHILDREN'S HOSPITAL

SJH/AMNCH Research Ethics Committee Secretariat
Claire Hartin Ph: 4142199
email: claire.hartin@amnch.ie

TALLAGHT, DUBLIN 24, IRELAND
TELEPHONE +353 1 4142000

Waiver of Ethical Approval

20 January 2016

RE: "MSc. Project"

Dear *Fionnuala*

Thank you for your recent correspondence to SJH/AMNCH Research Ethics Committee in which you enquired about ethical approval for your proposed MSc. project.

The SJH/AMNCH do not ordinarily concern themselves with research or service improvements that do not involve direct patient contact and therefore there are no ethical issues with proceeding.

Yours sincerely,

Claire Hartin
Secretary
SJH/AMNCH Research Ethics Committee

Appendix M: Trinity College Dublin Ethics Application

School of Computer Science and Statistics Research Ethical Application Form

Part A

Project Title: An investigation of the effect of a prescriber training intervention on prescription errors and the quality of prescriptions generated by an electronic prescribing system.....

Name of Lead Researcher (student in case of project work): Fionnuala Nevin.....

Name of Supervisor: Gaye Stephens and Tamasine Grimes.....

TCD E-mail: fnevin@tcd.ie..... Contact Tel No.: 086-1945281.....

Course Name and Code (if applicable): MSc in Health Informatics

Estimated start date of survey/research: 25/01/2016.....

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/dp/legislation.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: Fionnuala Nevin Date: 16/1/16
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
Does this study contain commercially sensitive material?		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		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 (records only. No direct patient contact)
--	----------	---

**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: Yelbi Chinnwala Newin Date: 16/1/16
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 or other TCD Ethics Committee approval has been received, please complete below.

External/TCD 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.
Approval received from St James's Hospital Risk & Legal Dept. and waiver from SJH/Tallaght Hospital Joint Ethics Committee. Email, application and waiver attached to this application

Signed: Yelbi Chinnwala Newin Date: 16/1/16
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 suitable for review by the SCSS Research Ethics Committee

Signed: Date:
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

Appendix N: Trinity College Dublin Ethics Approval

01/05/2016

Trinity College Dublin Mail - RE: [Research-ethics] Fionnuala Nevin Ethics Application 18/16



Fionnuala Nevin <fnevin@tcd.ie>

RE: [Research-ethics] Fionnuala Nevin Ethics Application 18/16

Bridget Gavin <Bridget.Gavin@scss.tcd.ie>

19 February 2016 at 09:09 Reply-To: Bridget.Gavin@scss.tcd.ie

To: Fionnuala Nevin <fnevin@tcd.ie>

Cc: Ethics TCD <research-ethics@scss.tcd.ie>

Hi Fionnuala

The Research Ethics committee has reviewed and approved your application. You may proceed with this study.

We wish you every success in your research.

Regards

Bridget

Bridget Gavin

School of Physics (Monday - Wednesday, +353 (1) 8962019)

Computer Science and Statistics (Wednesday – Friday, +3535 (0)1 8961445)

Trinity College Dublin

Mobile: +353 86 2162800

[Linked In](#)

From: Fionnuala Nevin

[mailto:fnevin@tcd.ie]

Sent: 18 February 2016 17:27

To: Bridget Gavin

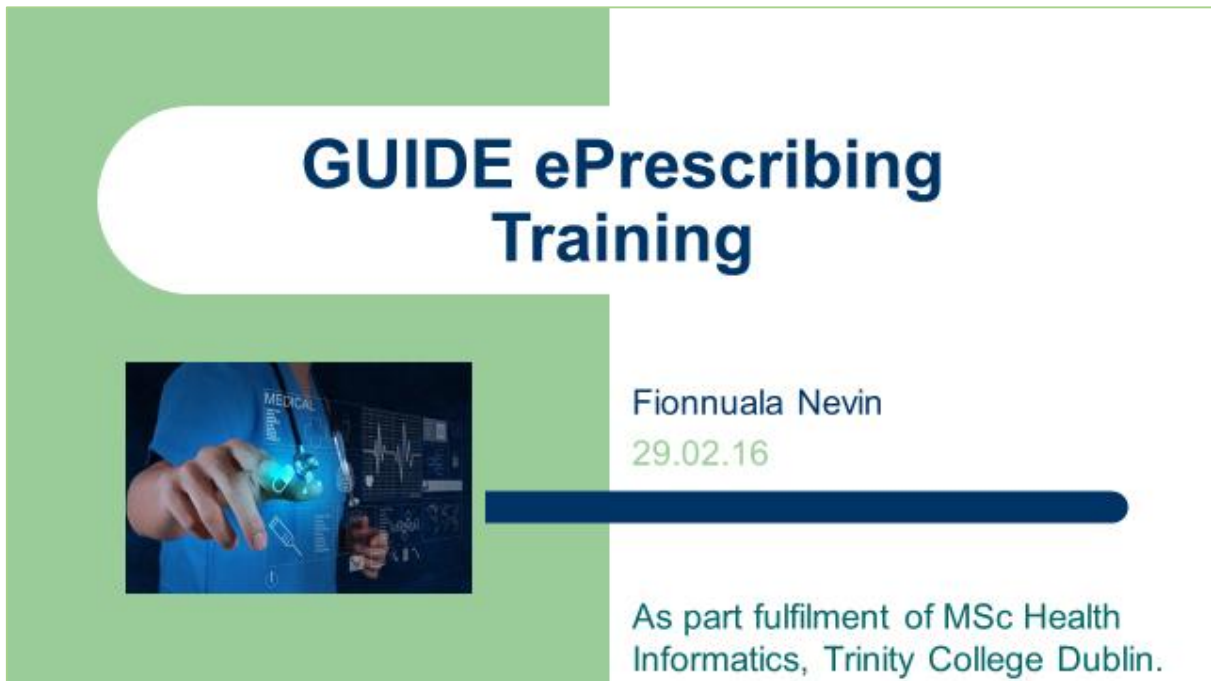
Subject: Re: [Research-ethics] Fionnuala Nevin Ethics Application 18/16

[Quoted text hidden]


<https://mail.google.com/mail/u/0/?ui=2&ik=bc4fb5493&view=pt&q=ethics%20approval&qs=true&search=query&msg=152f8c5adff28bed&siml=152f8c5adf...> 1/1

Appendix O: Training Presentation

Slide 1



**GUIDE ePrescribing
Training**



Fionnuala Nevin
29.02.16

As part fulfilment of MSc Health Informatics, Trinity College Dublin.

Slide 2



Overview of presentation


- Motivation for Training Session
- Findings of Prescription Audit
- Review of Findings
- Survey Feedback



Slide 3

Research Question

What is the effect of a prescriber training intervention on prescription errors generated by an electronic prescribing system?


A 3D illustration of a training session. A red 3D figure stands on the left, pointing towards a whiteboard. Five other 3D figures, colored in shades of blue and green, are seated at a long table with laptops, facing the whiteboard. The scene is set in a simple, clean environment.

Notes: Explanation of research undertaken, and research methods, were outlined.

Slide 4

Motivation

- Electronic prescribing is on the horizon
- Many factors will need to be considered
 - How the system is currently working
 - Training requirements
- Allow for audit and feedback about the system
 - Highlight any problems with the system

A 3D illustration of a white 3D figure standing next to a large, red, 3D question mark. The figure is gesturing towards the question mark with its right hand. The background is plain white.

Notes: Rationale for research was explained in slides 4 and 5.

Slide 5

Motivation

- Literature refers to the importance of ongoing support and training
- Lack of evidence or published literature to highlight why this is so important
- Make a case for resources for staff training



Slide 6

		Example
1.	Error in Prescription Fields Traditional type prescribing error	
1a	Incorrect Drug	Kivexa® prescribed instead of Triumeq®
1b	Incorrect Dose (including incorrect strength/volume OR incorrect unit)	
1c	Incorrect Form	
1d	Incorrect Route	
1e	Incorrect Frequency/Administration Details – includes as directed/as required	
2.	Error associated with Copying Prescription System-related prescribing error	
2a	"Dispensed" status repeated from previous prescription not removed	
2b	Details in "order comments" or "special instructions" field repeated from previous prescription that are no longer valid/appropriate (other than "dispensed status")	
3.	Error in Receipt of Task to pharmacy System-related prescribing error	
3a	Patient waiting for medications but no order received to pharmacy due to omission of prescription	
3b	Patient waiting for medications but no order received to pharmacy due to omission of task creation (for example medication was prescribed as part of the incorrect episode)	
3c	Pharmacy task generated but no note and no prescription attached	
4.	Error relating to pre-pack medicines System-related prescribing error	
4a	Pre-pack prescription ordered in error when the prescription must be dispensed in the pharmacy.	
4b	Pharmacy dispensed prescription ordered in error when the prescription was dispensed as a pre-pack by the clinician.	
5.	Clinical Error Traditional type prescribing error	
5a	Inappropriate prescription due to drug-drug interaction	
5b	Inappropriate prescription due to patient's allergy status	
5c	Inappropriate dose due to patient's renal function	
5d	Inappropriate prescription for other clinical reason – please give details in following column	

Notes: Pre-training audit method and error types were explained.

Slide 7

Pre-Training Audit Results

Key Findings:

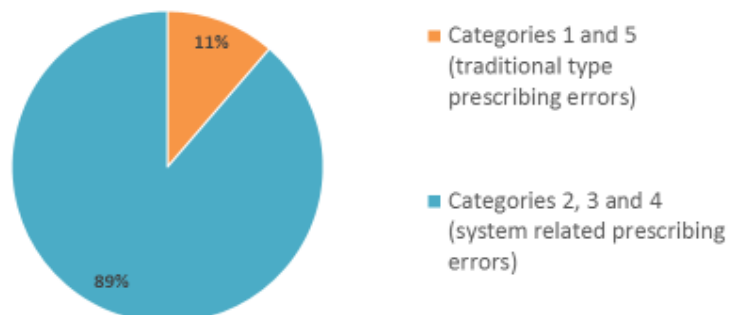
- 277 patients prescriptions were reviewed
- 167 (28%) of the 596 medications prescribed contained one or more errors/issues
- In total 203 errors/issues were found

Notes: Key findings from pre-intervention audit were outlined and explained in Slides 7-9. Note the results outlined were those prior to the removal of duplicate patients and therefore differ very slightly to those presented in the body of the dissertation.

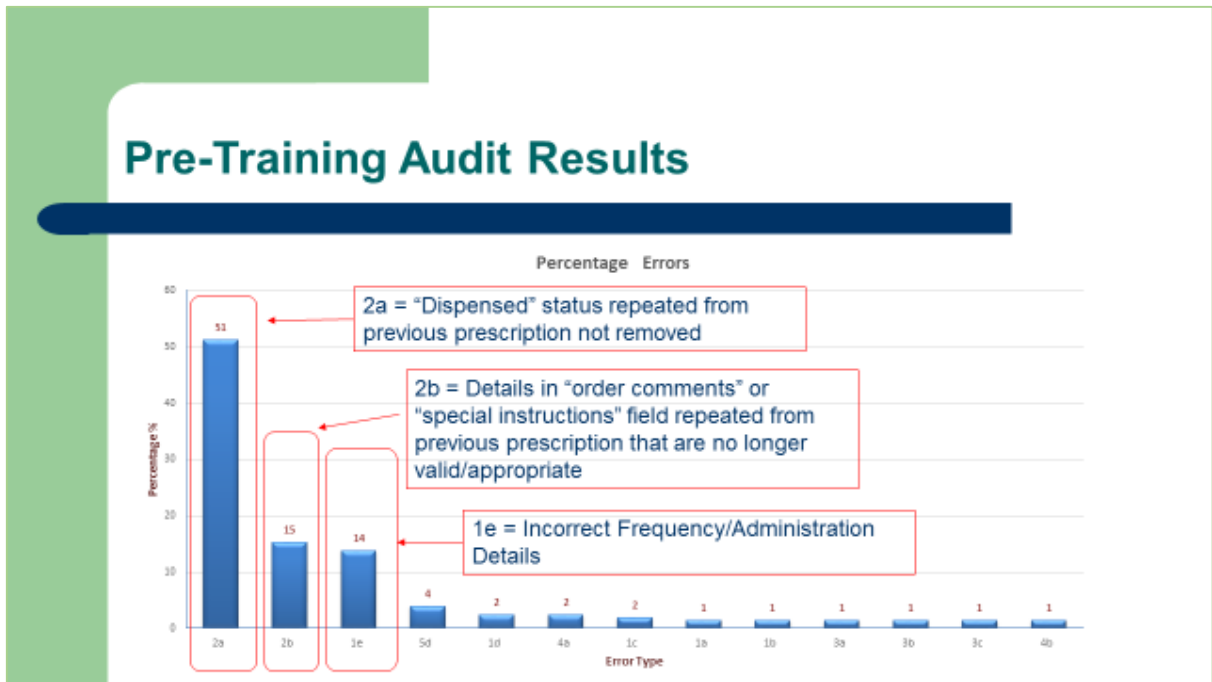
Slide 8

Pre-Training Audit Results

Types of Prescribing Errors

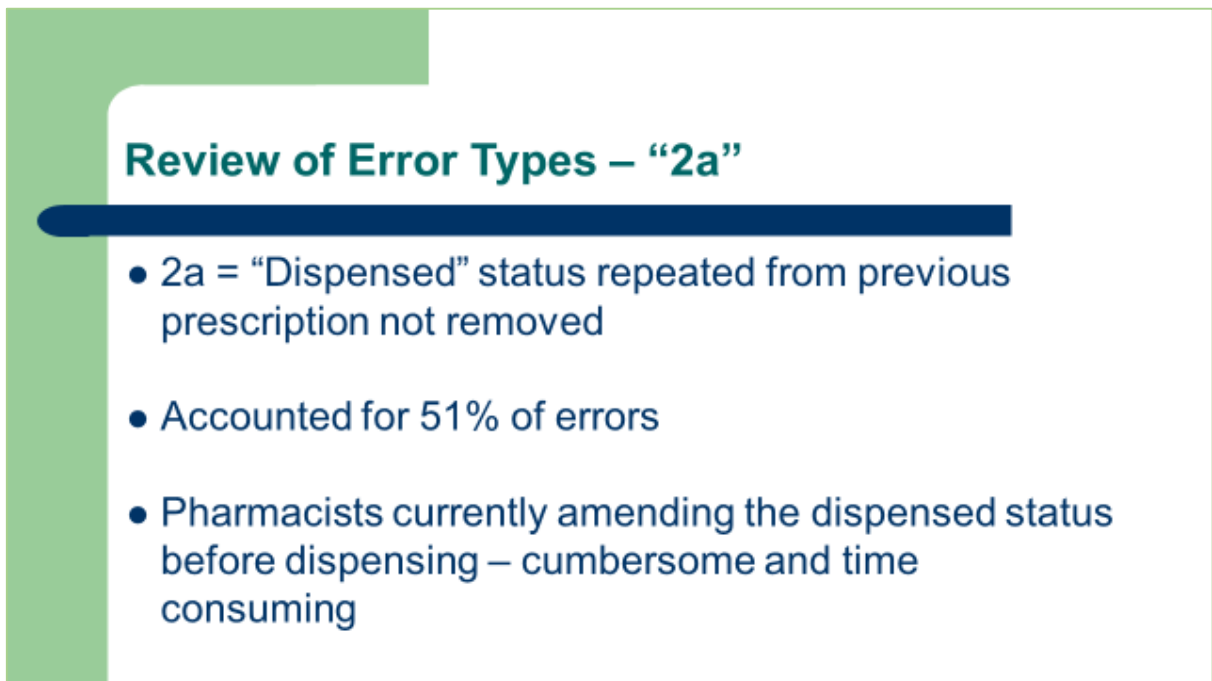


Slide 9



Notes: Distribution of error types was displayed. The top three most common errors were highlighted as these accounted for 80% of all errors.

Slide 10



Notes: Error type 2a was explained.

Slide 11

Review of Error Types – “2a”

- Survey Feedback:
 - 41% were not aware of the legal requirement to remove the word “dispensed” from the “dispensing status” field of copied prescriptions
- Legal requirement to remove the word dispensed as no further medications can be given to patients from a “dispensed” prescription
- Legislation = S.I. No. 540/2003 - Medicinal Products (Prescription and Control of Supply) Regulations 2003

Notes: Legislation pertaining to this error type was explained.

Slide 12

Review of Error Types – “2a”

Order 26/01/2016 11:27
Entered and electronically signed by [redacted] on 26/01/2016 at 11:27.

Status
Order Status:

Details
Strength Dose:
Strength Dose Unit:
Route of Administration:
Frequency:
As required:
Requested Start Date/Time:
Duration:
Duration Unit:
Stop Type:
Constant Indicator:
Dispense status:



Rx: 0651 ST. JAMES'S HOSPITAL
James's St, Dublin 8, Ireland
Tel: (+353-1) 410 3000

Patient Name: Joe Bloggs
Respiratory No: 1234567
Address: Test House
Test Street
DOB: 12.4.67

Date: 26.1.16
Clinician: Dr Bloggs
Referral sent to / discharged from: GU/BE Clinic
(Plan Department)
Worship (Details name of Allerg): NKDA

Drug Name & Strength	Dose	Frequency	Route	Quantity	Duration (if not ongoing)
Raltegravir	400mg	BD	PO	4/12	

St. James's Hospital
Pharmacy Department
26.01.16
Dispensed 4/12 PM

Comments (e.g. discontinued medicines)

Prescriber Signature: [Signature]
Prescriber Name (Printed/typed): Dr Bloggs
MCHN (Prescriber): 12345
PIN No. (Registered Nurse/Prescriber): 678

Notes: Error type was highlighted by showing a paper-based prescription with the word “dispensed” flagging that it has been completely dispensed and no more medications can be issued from this prescription.

Slide 13

Review of Error Types – “2a”

Modify 26/01/2016 11:39
Entered and electronically signed by [redacted] on 26/01/2016 at 11:39.
Ordered by [redacted]

Details After Before
Dispense status

Modify 26/01/2016 11:39
Entered and electronically signed by [redacted] on 26/01/2016 at 11:38.
Ordered by [redacted]

Details After Before
Dispense status

Notes: Screenshot was displayed of the electronic prescribing system, showing the steps that must be made to remove the “dispensed” status before dispensing and then adding the “dispensed” status again once the new prescription has been issued.

Slide 14

AKA: [redacted] Priority: [redacted] Location: OPD SUR Bloggs J Mt General BMS (1523) Episode: Outpatient (Pub) [22/02/2016 11:34 - 25/02/2016 17:18] Mobile: [redacted]

Menu

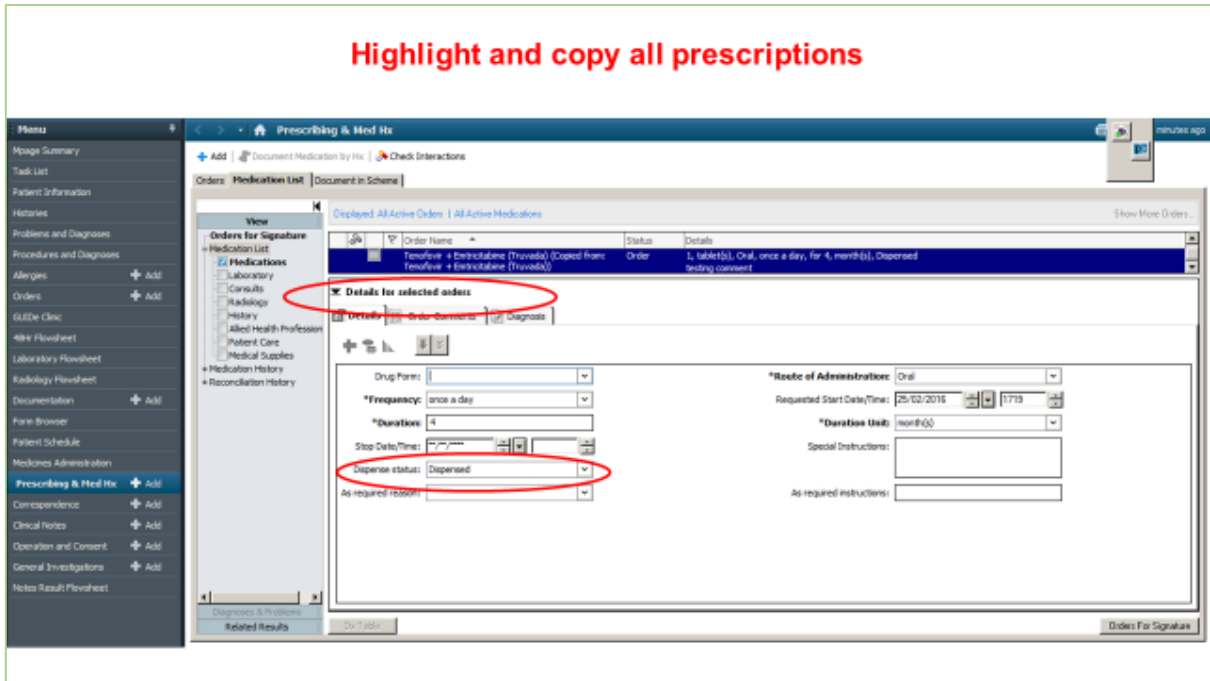
Prescribing & Med lib

Order Name	Status	Details
Darunavir (Darunavir tablets)	Ordered	800, sig, Oral, once a day, for 4, month(s), Dispensed
Rilpivirine (Rilpivirine tablets)	Ordered	350, sig, Oral, once a day, for 4, month(s), Test Comment
Tenofovir + Emtricitabine (Truvada)	Ordered	1, tablet(s), Oral, once a day, for 4, month(s), Dispensed

Notes: Slides 14 – 16 demonstrated how to remove the “dispensed” status when copying a prescription.

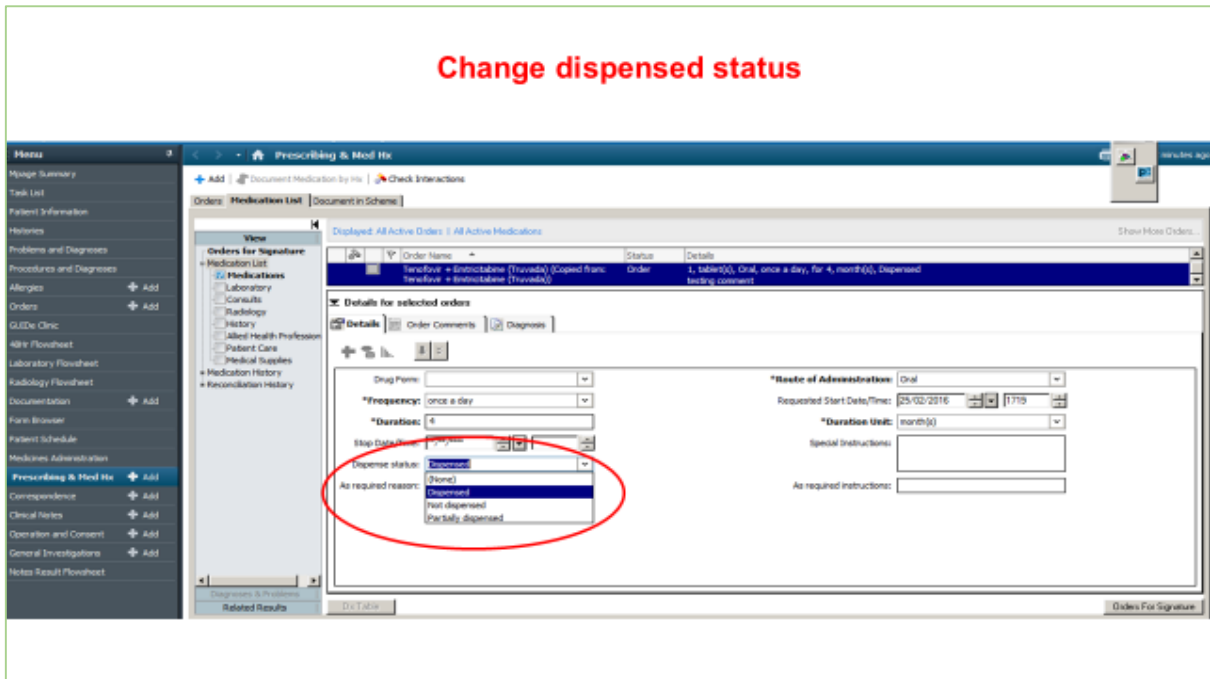
Slide 15

Highlight and copy all prescriptions



Slide 16

Change dispensed status



Slide 17

Review of Error Types – “2b”

- 2b = Details in “order comments” or “special instructions” field repeated from previous prescription that are no longer valid/appropriate (other than “dispensed status”)
- Accounted for 15% of errors
- 13% of these errors had happened more than once for copied prescription

Notes: Error type 2b was explained.

Slide 18

Review of Error Types – “2b”

- Comment originally entered July 2015

Order 25/01/2016 16:58
Entered and electronically signed by [redacted] on 25/01/2016 at 16:58.

Status
Order Status:

Details
Strength Dose:
Strength Dose Unit:
Route of Administration:
Frequency:
As required:
Requested Start Date/Time:
Duration:
Duration Unit:
Stop Type:
Constant Indicator:

Comment
dont dispense until CIR reviewed

Modify 25/01/2016 17:45
Entered and electronically signed by [redacted] on 25/01/2016 at 17:45.
Ordered by [redacted]

Details **After** **Before**
Dispense status: Dispensed

Comment
After
Before
dont dispense until CIR reviewed

Notes: Example of error type 2b were demonstrated.

Slide 19

The screenshot shows a medical software interface with a sidebar on the left and a main content area. The main content area displays a table of medications. The table has columns for 'Medications', 'Status', and 'Details'. The 'Details' column contains text for three medications: 'Doravir (Doravir tablets)', 'Ritonavir (Ritonavir tablets)', and 'Tenofovir + Emtricitabine (Truvada)'. Red circles highlight the following text in the 'Details' column: 'once a day, for 4, month(s), Dispensed', 'Test Comment', 'once a day, for 4, month(s), Dispensed', 'Special Instructions', and 'Testing comment'.

Notes: Slides 19 – 27 demonstrated how to edit/remove comments and special instructions when copying a prescription.

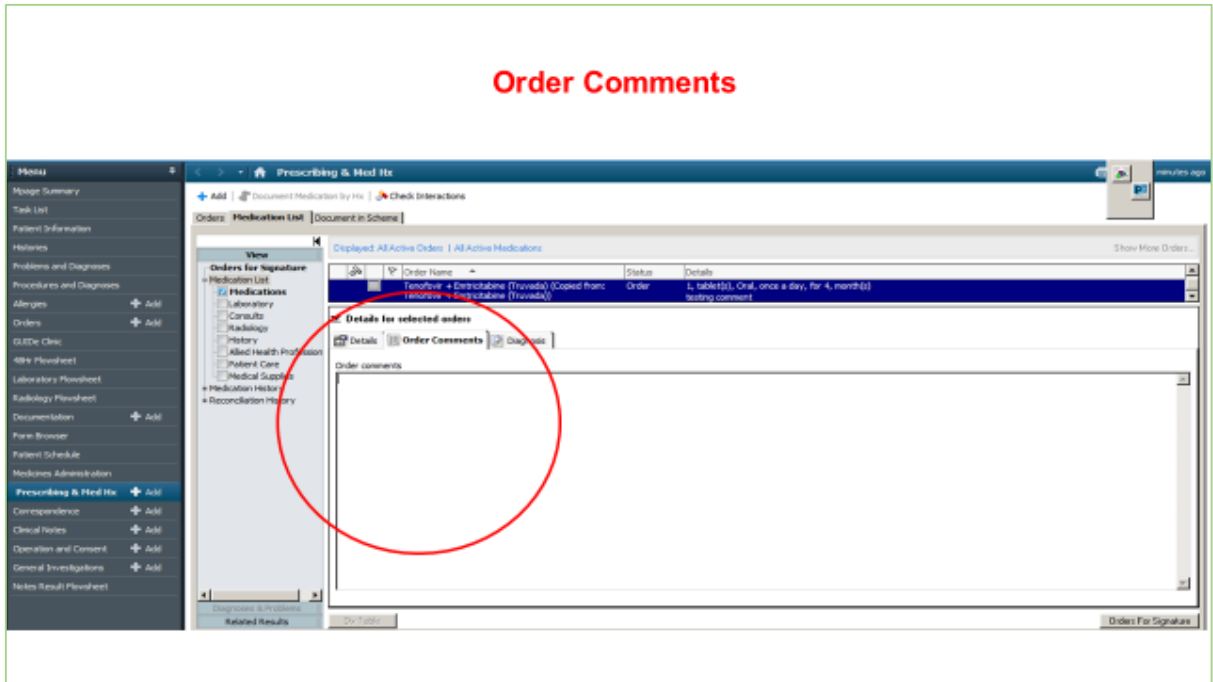
Slide 20

Highlight and copy all prescriptions

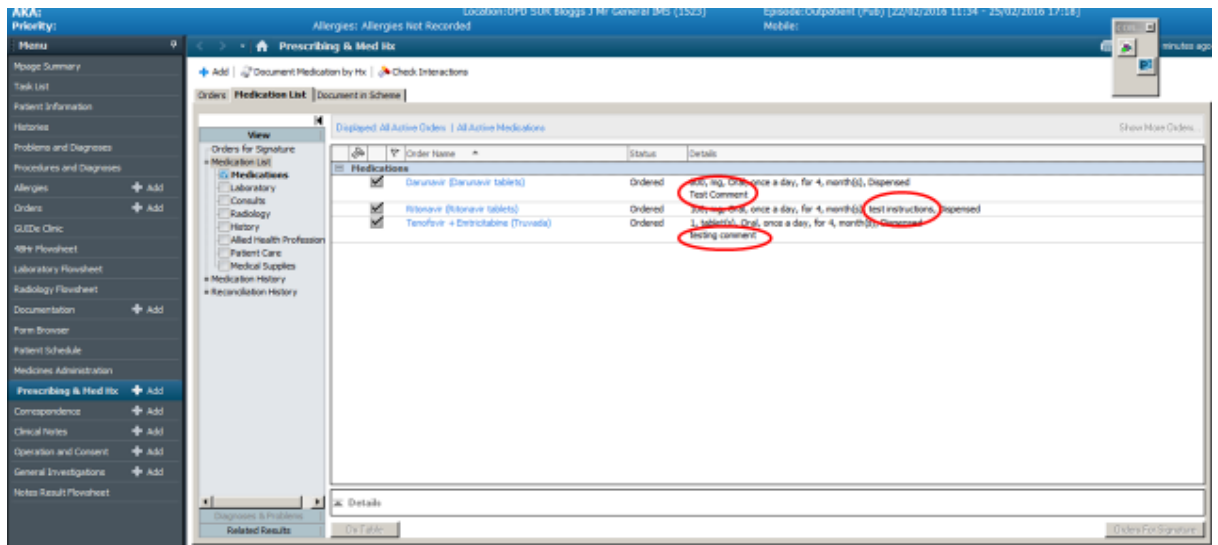
The screenshot shows the same medical software interface as Slide 19, but with the 'Details for selected orders' window open. The window displays various fields for the selected medication order. Red circles highlight the following fields: 'Details for selected orders', 'Special Instructions', and 'As required reason'.

Slide 21

Order Comments



Slide 22



Slide 23

Click on Truvada

The screenshot shows a software interface for 'Prescribing & Med Hx'. The main window displays 'Details for Tenofovir + Emtricitabine (Truvada)'. The 'Order Comments' tab is selected, but it is currently empty. A red arrow points from the text 'Click on Truvada' to the 'Order Comments' tab. Below the screenshot, the text 'Still don't see comment. Need to click on order comments to see' is displayed.

Still don't see comment. Need to click on order comments to see

Slide 24

Remove/edit comment and click next drug

The screenshot shows the same software interface as Slide 23. The 'Order Comments' tab is now active, and a text area below it contains the text 'testing comment'. A red circle is drawn around the 'Order Comments' tab and the text area. Below the screenshot, the text 'Remove/edit comment and click next drug' is displayed.

Remove/edit comment and click next drug

Slide 25

Click on Ritonavir

The screenshot shows a 'Prescribing & Med Hx' window. On the left is a navigation menu with 'Prescribing & Med Hx' selected. The main area displays a table of medication orders. The selected order is for Ritonavir (Ritonavir tablets). Below the table, the 'Details for Ritonavir (Ritonavir tablets)' form is visible. The 'Special Instructions' field contains the text 'Test instructions'. A red arrow points to this field.

Information in special instructions field this time. Less clicks to edit/remove

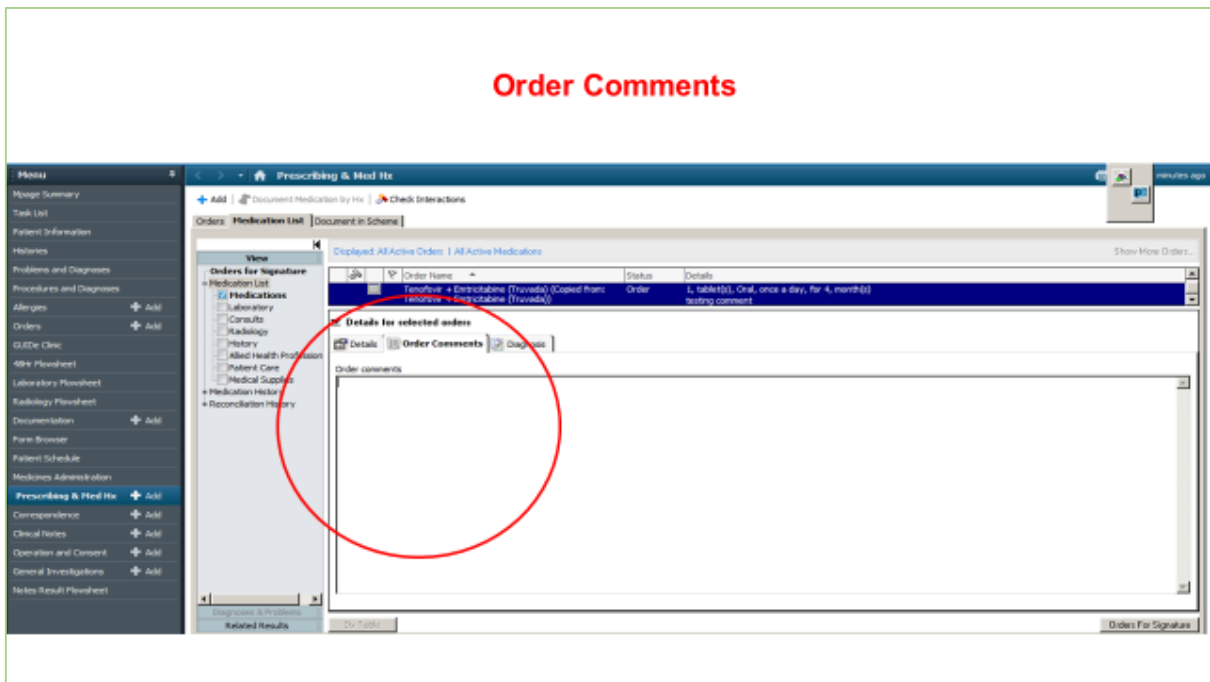
Slide 26

Highlight and copy all prescriptions

The screenshot shows the same 'Prescribing & Med Hx' window. In this view, the 'Details for selected orders' section is highlighted with a red circle. Within this section, the 'Special Instructions' field is also highlighted with a red circle. The 'Special Instructions' field is currently empty.

Slide 27

Order Comments



The screenshot displays a medical software interface with a sidebar on the left and a main content area. The sidebar includes various menu items such as 'Manage Summary', 'Task List', 'Patient Information', 'History', 'Problems and Diagnosis', 'Procedures and Diagnosis', 'Allergies', 'Orders', 'CDEr Clinic', '994 PlanSheet', 'Laboratory PlanSheet', 'Radiology PlanSheet', 'Documentation', 'Form Browser', 'Patient Schedule', 'Medication Administration', 'Prescribing & Med Hx', 'Correspondence', 'Clinical Notes', 'Operation and Consent', 'General Investigations', and 'Notes Result PlanSheet'. The 'Prescribing & Med Hx' menu item is highlighted. The main content area shows a 'Prescribing & Med Hx' window with a 'Medication List' and a 'Details for selected orders' section. The 'Order Comments' tab is highlighted with a red circle. The 'Order Comments' section contains a text area for entering comments.

Slide 28

Review of Error Types – “1e”

- 1e = Incorrect Frequency/Administration Details
- Accounted for 14% of errors
- Examples:
 - As directed/as required as frequency
 - Incorrect duration
- 11% of these errors had happened more than once for copied prescription

Notes: Error type 1e was explained.

Slide 29

Review of Error Types – “1e”

Ribavirin (Ribavirin tablets)

Additional Info | Comments | Details | Results | History

Modify 26/01/2016 13:02

Order 26/01/2016 12:29

Entered and electronically signed by [redacted] on 26/01/2016 at 13:02.

Frequency: **After**

Order 26/01/2016 12:29

Entered and electronically signed by [redacted] on 26/01/2016 at 12:28.

Status: Ordered

Details:

Strength Dose: 400

Strength Dose Unit: mg

Route of Administration: Oral

Frequency: **As directed**

As required: Yes

Duration: 5

Duration Unit: month(s)

Requested Start Date/Time: 26/01/2016 12:29

Stop Type: Physician Stop

Constant Indicator: No

As required reason: C7H6B1 - See Order Comments

Notes: Examples of error type 1e were demonstrated in slides 29 and 30.

Slide 30

Review of Error Types – “1e”

Co-amoxiclav (Augmentin tablets)

Order 26/01/2016 15:04

Entered and electronically signed by [redacted] on 26/01/2016 at 15:04.

Status: Ordered

Details:

Strength Dose: 625

Strength Dose Unit: mg

Route of Administration: Oral

Frequency: three times a day

Duration: 5

Duration Unit: week(s)

Requested Start Date/Time: 26/01/2016 15:04

Stop Date/Time: 01/03/2016 15:03

Stop Type: Physician Stop

Constant Indicator: No

Slide 31

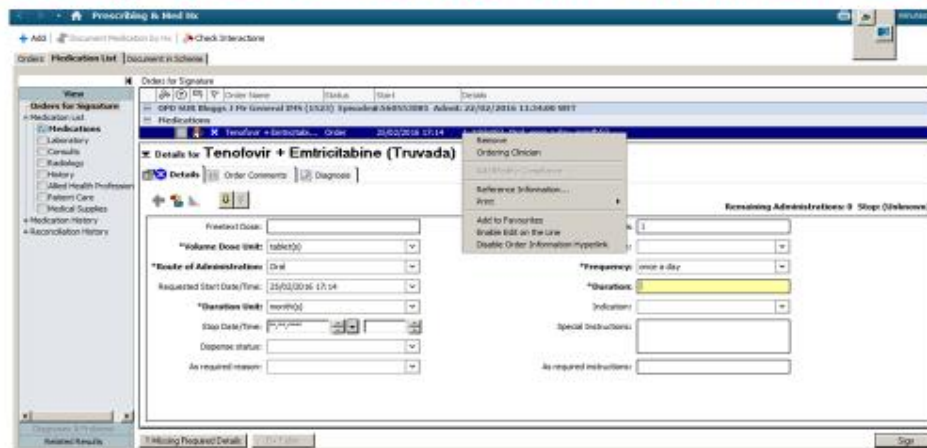
Survey Feedback

- Preferred training method is one-to-one with lead EPR clinician – 69%
- 65% have a favourites folder
- 47% did not know how to add order sentences to favourites folder
- 47% did not know how to prescribe a medicine that you cannot find in drug catalogue

Notes: Some of the findings of the questionnaire were highlighted and discussed.

Slide 32

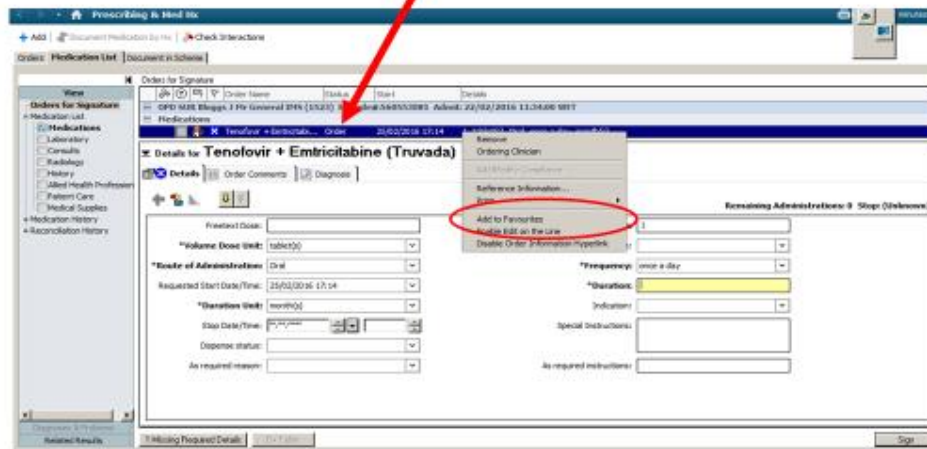
Adding Order Sentences to Favourites Folder



Notes: As almost 50% of questionnaire respondents did not know how to add an order sentence to their favourites folder, this was demonstrated in slides 32 – 34.

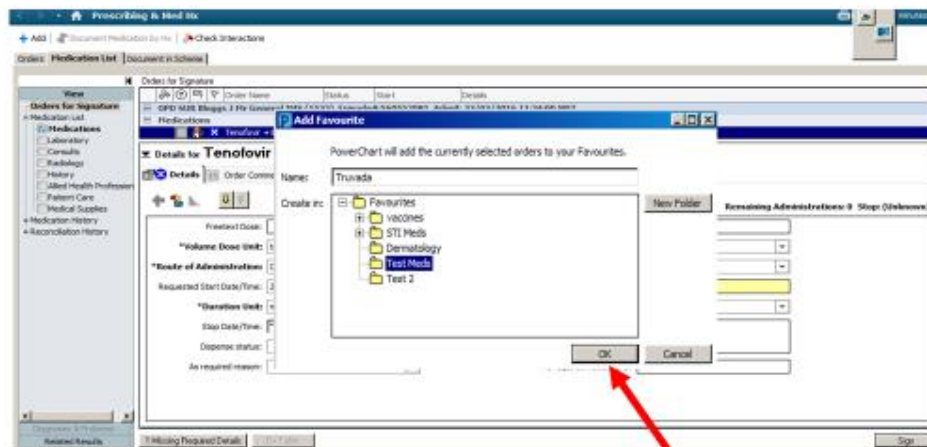
Slide 33

Right click on blue highlighted order sentence



Click Add to Favourites

Slide 34

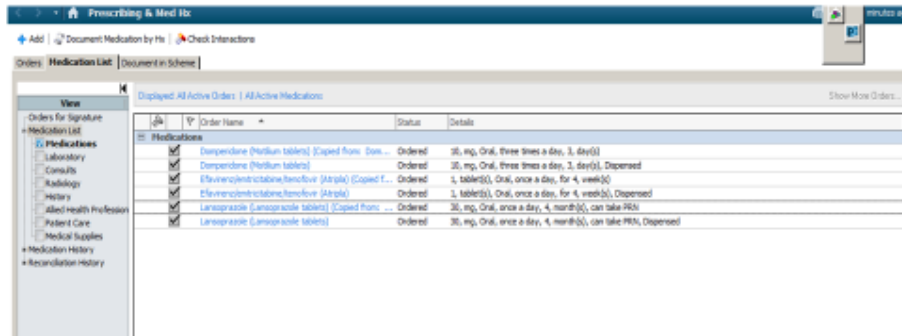


Choose folder you want and click OK

Slide 35

Layout of Medications

- Survey feedback mentioned medications not appearing in chronological order for some users

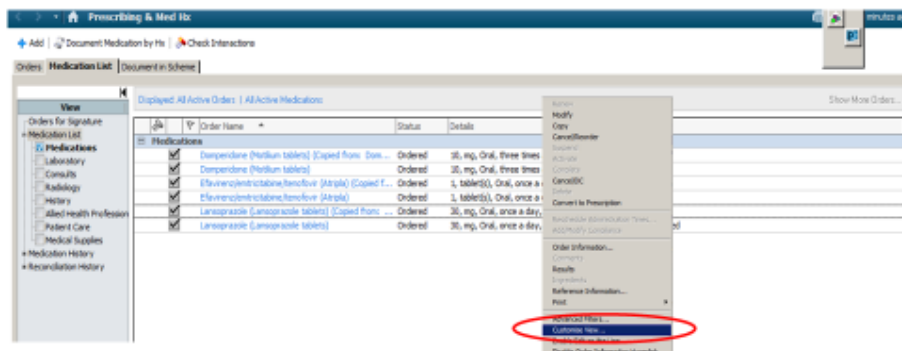


Notes: Several respondents highlighted that the display/layout of the medications in the patients prescribing and medication history made it difficult to establish what was last prescribed to a patient. A method to rearrange the medications in chronological order was demonstrated in slides 35 – 38.

Slide 36

Layout of Medications

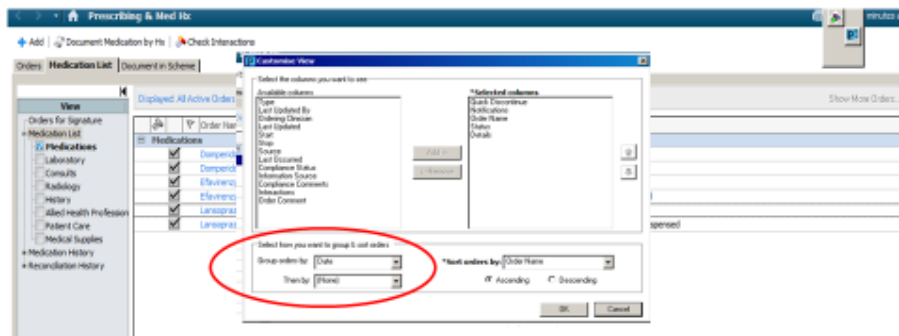
- Right click and select customise view



Slide 37

Layout of Medications

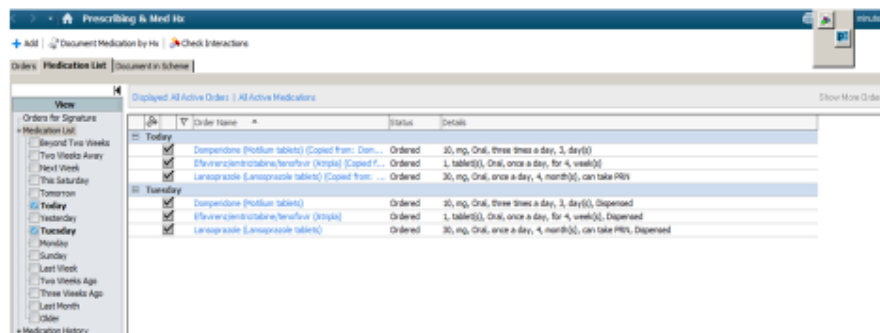
- Select group orders by DATE



Slide 38

Layout of Medications

- Then appears chronologically



Key messages

- Dispensed status must be removed for legal reasons
- Before signing - check dispensed status/comments/special instructions
- May need to drill down within individual drug to remove order comments
- Watch out for as required/as directed frequency/directions

Notes: The key learning points were reviewed at the end of the presentation. Questions were also welcomed and asked at the end. A discussion was had with the group on the various topics raised and other aspects of the electronic prescribing system.

Appendix P: Questionnaire Results - Qualtrics Report

Final Report

Last Modified: 29/02/2016

1. DECLARATION

- I am 18 years or older and am competent to provide consent.
- I have read and understood a document providing information about this research. Any questions I had have been answered to my satisfaction.
- I agree that my data is used for scientific purposes and may be published in scientific publications in a way that does not reveal my identity.
- I understand that in the extremely unlikely event that any illicit activities are made known, these will be reported to appropriate authorities.
- I freely and voluntarily agree to be part of this research study, though without prejudice to my legal and ethical rights.
- I understand that I may refuse to answer any question and withdraw at any time without penalty.
- I understand that my participation is fully anonymous and no personal details about me will be recorded.
- I understand that if I or anyone in my family has a history of epilepsy then I am proceeding at my own risk.
- I have received a copy of this agreement.

Do you agree to the above declaration and are you happy to proceed with the questionnaire?

#	Answer	Response	%
1	Yes	17	100%
2	No	0	0%
	Total	17	100%

Statistic	Value
Min Value	1
Max Value	1
Mean	1.00
Variance	0.00
Standard Deviation	0.00
Total Responses	17

2. Please state your job position:

#	Answer	Response	%
1	Consultant	4	24%
2	GUM Specialist	2	12%
3	Registrar	6	35%
4	GP Trainee	0	0%
5	Nurse Prescriber	4	24%
6	Other	1	6%
	Total	17	100%
Statistic		Value	
Min Value		1	
Max Value		6	
Mean		3.06	
Variance		2.68	
Standard Deviation		1.64	
Total Responses		17	

3. How long have you personally been using the Cerner® EPR in St James's Hospital to prescribe medications?

#	Answer	Response	%
1	Less than 6 months	2	12%
2	6 months to 1 year	4	24%
3	More than 1 year but less than 2 years	0	0%
4	2 years or more	11	65%
	Total	17	100%
Statistic		Value	
Min Value		1	
Max Value		4	
Mean		3.18	
Variance		1.40	
Standard Deviation		1.19	
Total Responses		17	

4. Have you previously used an electronic prescribing system prior to working in the GUIDE clinic?

#	Answer	Response	%
1	Yes	3	18%
2	No	14	82%
	Total	17	100%

Statistic	Value
Min Value	1
Max Value	2
Mean	1.82
Variance	0.15
Standard Deviation	0.39
Total Responses	17

5. If yes, which electronic prescribing system did you use?

#	Answer	Response	%
1	Cerner® electronic prescribing system	0	0%
2	Other	4	100%
	Total	4	100%

Statistic	Value
Min Value	2
Max Value	2
Mean	2.00
Variance	0.00
Standard Deviation	0.00
Total Responses	4

6. When did you last receive training* on how to use the Cerner® electronic prescribing system?

#	Answer	Response	%
1	Less than 3 months ago	2	12%
2	3 to 6 months ago	1	6%
3	More than 6 months ago	13	76%
4	No training received	1	6%
Total		17	100%
Statistic		Value	
Min Value		1	
Max Value		4	
Mean		2.76	
Variance		0.57	
Standard Deviation		0.75	
Total Responses		17	

7. Which of the following electronic prescribing training interventions have you undertaken in the last year (please tick all that apply):

#	Answer	Response	%
1	One-to-one training session with Dr. Grainne Courtney lasting less than 20 minutes	9	53%
2	One-to-one training session with Dr. Grainne Courtney lasting over 20 minutes	2	12%
3	Classroom training during a lunchtime education session	5	29%
4	Read the EPR training manual	0	0%
5	Attended an IMS led EPR training session	3	18%
6	Informal training from another staff member	8	47%
7	No training received in the last year	5	29%
8	Other (please give details):	1	6%
Other (please give details):			
Statistic		Value	
Min Value		1	
Max Value		8	
Total Responses		17	

8. Of the training interventions which you received, which did you find the most beneficial for the purpose of using the electronic prescribing function in the Cerner® EPR?

#	Answer	Response	%
1	One-to-one training session with Dr. Grainne Courtney lasting less than 20 minutes	9	56%
2	One-to-one training session with Dr. Grainne Courtney lasting over 20 minutes	2	13%
3	Classroom training during a lunchtime education session	2	13%
4	Reading the EPR training manual	0	0%
5	Attending the IMS led EPR training session	2	13%
6	Informal training from another staff member	0	0%
7	No training received in the last year	0	0%
8	Other (please give details):	1	6%
	Total	16	100%
Other (please give details):			
Statistic	Value		
Min Value	1		
Max Value	8		
Mean	2.31		
Variance	4.23		
Standard Deviation	2.06		
Total Responses	16		

9. Overall, do you prefer prescribing medications on paper using handwriting or on the Cerner® EPR electronically?

#	Answer	Response	%
1	Prefer prescribing on paper using handwriting	0	0%
2	Prefer prescribing on the Cerner® EPR electronically	16	94%
3	Do not have a preference	1	6%
Total		17	100%
Statistic		Value	
Min Value		2	
Max Value		3	
Mean		2.06	
Variance		0.06	
Standard Deviation		0.24	
Total Responses		17	

10. Please give the main reason for your choice above:

Text Response	
<i>Details available from the researcher on request.</i>	
Statistic	Value
Total Responses	12

11. Do you have a favourites folder from which you select commonly prescribe medicines?

#	Answer	Response	%
1	Yes	11	65%
2	No	6	35%
Total		17	100%
Statistic		Value	
Min Value		1	
Max Value		2	
Mean		1.35	
Variance		0.24	
Standard Deviation		0.49	
Total Responses		17	

12. Do you know how to add order sentences to your favourites folder?

#	Answer	Response	%
1	Yes	9	53%
2	No	8	47%
	Total	17	100%
Statistic		Value	
Min Value		1	
Max Value		2	
Mean		1.47	
Variance		0.26	
Standard Deviation		0.51	
Total Responses		17	

13. On average, how easy is it to find a medicine that you are looking for – other than those in a favourites folder?

#	Answer	Response	%
1	Very Difficult	0	0%
2	Difficult	0	0%
3	Somewhat Difficult	1	6%
4	Neutral	1	6%
5	Somewhat Easy	5	31%
6	Easy	8	50%
7	Very Easy	1	6%
	Total	16	100%
Statistic		Value	
Min Value		3	
Max Value		7	
Mean		5.44	
Variance		0.93	
Standard Deviation		0.96	
Total Responses		16	

14. Do you know how to prescribe a medicine that you cannot find in the drug catalogue – i.e. you cannot find it when you search for it?

#	Answer	Response	%
1	Yes	9	53%
2	No	8	47%
	Total	17	100%
Statistic		Value	
Min Value		1	
Max Value		2	
Mean		1.47	
Variance		0.26	
Standard Deviation		0.51	
Total Responses		17	

15. For patients who require a repeat prescription of their previously prescribed medications, do you prefer to copy prescriptions from the previous entry or to enter them as original prescriptions?

#	Answer	Response	%
1	Copy the previous prescription	10	67%
2	Enter them as an original prescription	5	33%
Total		15	100%

Statistic	Value
Min Value	1
Max Value	2
Mean	1.33
Variance	0.24
Standard Deviation	0.49
Total Responses	15

16. Please give the reason(s) for your answer above:

#	Answer	Response	%
1	Quicker	11	69%
2	Less potential for error	12	75%
3	Less familiar with other method	2	13%
4	Other (please give details):	2	13%

Other (please give details):	
<i>Details available from the researcher on request.</i>	
Statistic	Value
Min Value	1
Max Value	4
Total Responses	16

17. Are you aware of the legal requirement to remove the word “dispensed” from the "dispensing status" field of copied prescriptions?

#	Answer	Response	%
1	Yes	10	59%
2	No	7	41%
	Total	17	100%

Statistic	Value
Min Value	1
Max Value	2
Mean	1.41
Variance	0.26
Standard Deviation	0.51
Total Responses	17

18. What, if any, is the main improvement you would like to see in the current Cerner® EPR prescribing function? (please give details in the box below)

Text Response	
<i>Details available from the researcher on request.</i>	
Statistic	Value
Total Responses	12

19. Please enter any additional comments you may have regarding electronic prescribing in the GUIDE clinic or this research in the box below:

Text Response	
<i>Details available from the researcher on request.</i>	
Statistic	Value
Total Responses	6

20. The questionnaire is now complete. You may exit without submitting if you would prefer, however, it is the researchers' preference that the questionnaire kindly be submitted. Please state your preference for proceeding:

#	Answer	Response	%
1	Submit questionnaire	17	100%
2	Do no submit questionnaire	0	0%
	Total	17	100%
Statistic			Value
Min Value			1
Max Value			1
Mean			1.00
Variance			0.00
Standard Deviation			0.00
Total Responses			17