The evolving landscape of electronic prescribing in UK secondary care:

Exploration of uptake, benefits, and challenges

ZAMZAM AHMED

A thesis submitted to the UCL School of Pharmacy for the degree of Doctor of Philosophy in the Department of Practice and Policy

> June 2016 UCL SCHOOL OF PHARMACY

> > Page 1 of 305

PLAGARISM STATEMENT

This thesis describes research conducted at the UCL School of Pharmacy between January 2011 and August 2015 under the supervision of Professor Nicholas Barber, Professor Bryony Dean Franklin and Doctor Yogini Jani.

I confirm that the research described in the present thesis is original and that any parts of the work that have been conducted in collaboration with colleagues are clearly indicated. I also confirm that I have written all the text of the present dissertation and have clearly indicated citation of any text of that has already appeared in publication.

Date: 27/06/2016

Signature: Zamzam Ahmed

PUBLICATIONS FROM THIS THESIS

Publications:

Ahmed Z, McLeod MC, Barber N, Jacklin A, Franklin BD (2013). **The Use and Functionality of Electronic Prescribing Systems in English Acute NHS Trusts: A Cross-Sectional Survey.** PLoS ONE 8(11): e80378. doi:10.1371/journal.pone.0080378

Ahmed Z, Barber N, Jani Y, Garfield S, Franklin BD (2016). **Economic impact of electronic prescribing in the hospital setting: a systematic review.** The International Journal of Medical Informatics. April 2016 Volume 88, Pages 1–7. DOI: http://dx.doi.org/10.1016/j.ijmedinf.2015.11.008

Ahmed Z, Garfield S, Jani Y, Jheeta S, Franklin BD (2016). Impact of electronic prescribing on patient safety in hospitals: implications for the UK. Clinical Pharmacist, Vol 8, No 5, online | DOI:

10.1211/CP.2016.20201013

Presentations:

The evolving landscape of EP in UK secondary care. The 2nd North West London Research Symposium for Health Professions 10 September 2014

ABSTRACT

Computerisation of healthcare delivery is frequently proposed as a solution to improve the quality and safety of patient care, both internationally and within the UK. This includes electronic prescribing (EP) in the hospital setting, which is the focus of this thesis. This work aims to shed some light into issues related to EP utilisation including the extent of usage in UK hospitals, potential challenges of deployment process and the economic impact of EP systems use.

A census of EP systems in English acute trusts found that some form of EP was used by 69% of 101 respondent hospitals. More than half had more than one system in use, representing 60 different systems. The most common were systems used for discharge prescribing followed by specialist chemotherapy systems. Only 13% of respondent hospitals used inpatient electronic prescribing across all adult medical and surgical wards. Overall, 40% of systems were developed 'in-house'. Decision support functionality varied widely. Semi structured interviews were conducted to further explore the phenomenon of multiple EP systems within a single hospital.

An evaluative framework was adapted to analyse data and interviews from a case study of an integrated EP system adoption to explore the complexity of the implementation process, establish key elements which facilitate the process and identify potential challenges.

A systematic review of international EP economic evaluations seems to suggest potential financial benefits of EP systems. However, it is difficult to reach a definitive answer as to whether EP provides value for money due to uncertainty surrounding costs and outcomes measured, and limitations in study design. Moreover, extrapolating the evidence to the UK context is difficult.

In conclusion, UK healthcare is in an interim phase aiming to achieve complete systems interoperability. The challenge is to manage the implications of the current interim phase while driving technology use forward.

ACKNOWLEDGEMENTS

The completion of research would not have been achieved without the contribution of the following people:

I would like to express my appreciation to, **Professor Nick Barber**, **Professor Bryony Dean Franklin**, and **Dr Yogini Jani** for their continuous encouragement and persistent help during the course of my PhD degree. They have shaped me to become an independent and a confident researcher.

I would like to express my gratitude to the UCL School of Pharmacy Oversees Awards and Imperial College NHS Trust for funding my degree.

I owe my deepest gratitude to **Dr Monsey McLeod** for her work in the survey and **Dr Sara Garfield** for her work in the economic systematic review. I also would like to extend my appreciation to the **Centre for Medication Safety and Service Quality** at ICHNT for their assistance.

My sincere thanks goes to **Professor Ann Jacklin** whose expertise, understanding, and wisdom have added considerably to my experience.

I wish to express my sincere thanks to all participants who took part in my pilot studies and research interviews. Without your contribution completing this thesis would have been impossible.

I am heartily thankful to **Dr Sarah Clifford** for her support. You were always there cheering me up and stood by me through the good times and bad.

I thank my examiners, **Professor Graham Davies** and **Dr Henry Potts** for a challenging yet enjoyable VIVA and their constructive comments.

My son, **Adam**, you were the best thing I have achieved during my PhD. You have been my companion throughout my studies and I dedicate this thesis to you. Thank you for teaching me to put things into perspectives.

I also thank my **parents** and **brothers** for the unceasing encouragement, financial support and attention. Finally, I am grateful to my **husband** who supported me throughout this venture. Thank you for existing.

ABBREVIATIONS

A&E	Accident and emergency
ADE	Adverse drug event
AHRQ	The Agency for Healthcare Research and Quality
BAs	Before/after studies
СВА	Cost benefit analysis
CCTs	Controlled clinical trials
CDSS	Computerised decision support systems
CEA	Cost effectiveness analysis
CfH	The NHS Connecting for health
CIVIs	Continuous intravenous infusions
ClinDocs	Clinical Documentation
СМА	Cost minimisation analysis
CPOE	Computerised provider (physician) order entry
	system
CPs	system Chief pharmacists
CPs CQC	system Chief pharmacists Care Quality Commission
CPs CQC CQUIN	system Chief pharmacists Care Quality Commission The Commissioning for Quality and Innovation
CPs CQC CQUIN CUA	system Chief pharmacists Care Quality Commission The Commissioning for Quality and Innovation Cost utility analysis
CPs CQC CQUIN CUA DCWs	system Chief pharmacists Care Quality Commission The Commissioning for Quality and Innovation Cost utility analysis Data collection worksheets
CPs CQC CQUIN CUA DCWs DDM	system Chief pharmacists Care Quality Commission The Commissioning for Quality and Innovation Cost utility analysis Data collection worksheets Design decision matrix
CPs CQC CQUIN CUA DCWs DDM DoH	system Chief pharmacists Care Quality Commission The Commissioning for Quality and Innovation Cost utility analysis Data collection worksheets Design decision matrix Department of Health
CPs CQC CQUIN CUA DCWs DDM DoH E.H.R	system Chief pharmacists Care Quality Commission The Commissioning for Quality and Innovation Cost utility analysis Data collection worksheets Design decision matrix Department of Health Electronic health record
CPs CQC CQUIN CUA DCWs DDM DoH E.H.R EHI	system Chief pharmacists Care Quality Commission The Commissioning for Quality and Innovation Cost utility analysis Data collection worksheets Design decision matrix Department of Health Electronic health record eHealth initiatives
CPs CQC CQUIN CUA DCWs DDM DoH E.H.R EHI eMAR	system Chief pharmacists Care Quality Commission The Commissioning for Quality and Innovation Cost utility analysis Data collection worksheets Design decision matrix Department of Health Electronic health record eHealth initiatives Electronic medical administration chart
CPs CQC CQUIN CUA DCWs DDM DoH E.H.R EHI eMAR EP	system Chief pharmacists Care Quality Commission Care Quality Commission The Commissioning for Quality and Innovation Cost utility analysis Data collection worksheets Data collection worksheets Design decision matrix Department of Health Electronic health record eHealth initiatives Electronic medical administration chart Electronic prescribing

administration

EPR	Electronic patient record
GP	General practitioner
HIMSS	The Health Information Management Systems
	Society
ніт	Health information technology
HSS	The U.S. Department of Health and Human
ONC	Services Office of the National Coordinator for
	Health Information Technology
ICHIS	Integrated computerised hospital information
	system
ICU	Intensive care unit
ΙΟΜ	The Institute of Medicine
п	Information technology
ITS	Interrupted time series
LOS	Length of stay
LPfIT	The London Program for IT
Mpages	Information dashboards
NIB	The national information board
NPfIT	The national program for IT
NPSA	The national patient safety agency
PACS	Picture archiving and communication systems
PAS	Patient administration system
QALY	Quality adjusted life year
RCT	Randomised controlled trial
RPS	The Royal Pharmaceutical Society
SIG	Special interest group
USHP	Unique system-hospital pair

Table of Contents

PLAGARISM STATEMENT	2
PUBLICATIONS FROM THIS THESIS	3
ABSTRACT	4
ACKNOWLEDGEMENTS	5
ABBREVIATIONS	6
List of Figures	15
List of Tables	
Copyright material statement:	
Thesis overview:	
Chapter 1: Introduction	
1.1 Technology deployment in healthcare	21
1.2 Electronic prescribing:	24
1.2.1 Definitions:	24
1.2.2 Scope and variations of EP systems	25
1.2.3 Integrated systems versus 'best of breed' approach	
1.2.4 Potential benefits of EP use:	
1.3 UK EP History	33
1.3.1 Pharmacy systems evolution	
1.3.2 EP systems	
1.3.3 Cancer EP systems:	
1.3.4 Discharge systems:	
1.3.5 The NHS National Programme for IT	
1.3.6 The recent government IT strategy	
1.3.7 EP use elsewhere:	40
1.4 Conclusion:	41
1.5 Thesis aim and objectives:	

2.1 Introduction:	
2.2 Aim and objectives:	
2.3 Methodology:	
2.3.1 Scope of the survey:	
2.3.2 Survey and sample design:	
2.3.3 Approach to the questionnaire:	
2.3.4 Methods to maximise the response rate	:
2.4 Methods:	
2.4.1 Study population:	
2.4.2 Questionnaire development:	
2.4.3 Survey implementation strategy	
2.4.4 Management of survey responses:	
2.4.5 Ethics	
2.5 Results:	
2.5.1 Respondent characteristics	
2.5.2 Prevalence of EP use	
2.5.3 Stages of the patient pathway and exter	nt of organisational
deployment	
2.5.4 EP systems:	
2.5.5 Future plans for EP implementation:	
2.6 Discussion:	
2.6.1 Main findings:	
2.6.2 Comparison with previous research:	
2.6.3 Implications for practice:	
2.6.4 Strength and limitations of this survey:	
2.6.5 Recommended future research:	

2.7 Conclusions:	85
Chapter 3 Qualitative study exploring the phenomenon of m	nultiple
electronic prescribing systems within a single healthcare o	rganisation:
	86
3.1 Background:	
3.2 Aim and objectives:	
3.3 Methodology:	87
3.3.1 Conceptual framework:	87
3.3.2 Considerations for data collection:	88
3.3.3 Considerations for data analysis:	89
3.4 Methods:	92
3.4.1 Participant selection	92
3.4.2 Pilot study	97
3.4.3 Data collection	97
3.4.4 Data analysis	
3.4.5 Ethics approval:	
3.5 Results:	
3.5.1 Study participants:	
3.5.2 Findings:	102
3.6 Discussion	122
3.6.1 Key findings:	122
3.6.2 Implications for current practice:	124
3.6.3 Strengths and limitations of the study:	125
3.6.4 Future research recommendations:	126
3.7 Conclusion	127
Chapter 4 Implementation of an electronic prescribing and	medicines
administration system integrated into an electronic health r	ecord in an
NHS trust: Stage one-participant observation	128

4.1 Background - chapters four and five:	
4.2 Introduction:	
4.3 Aim and objectives:	
4.4 Methodology:	
4.4.1 Approach:	
4.4.2 Participant observation:	
4.4.3 Data analysis:	
4.5 Methods:	
4.5.1 The study context:	
4.5.2 Data collection:	
4.5.3 Data management and analysis:	
4.5.4 Ethics:	
4.6 Results:	
4.6.1 Project management framework:	
4.6.2 Key themes emerged from the observations:	
4.7 Discussion:	
4.7.1 Interpretations of the main findings:	
4.7.2 Strengths and limitations of the present study:	
4.8 Conclusion:	
Chapter 5 Implementation of an electronic prescribing a	nd medicines
administration system integrated into an electronic heal	th record in an
NHS trust: Stage two - Case study	
5.1 Introduction:	
5.2 Aim and objectives:	
5.3 Methodology:	
5.3.1 Case study research	
5.3.2 Data collection approach:	
5.3.3 The theoretical approach:	

5.3.4 Data analysis approach: 175	5
5.4 Methods:	7
5.4.1 The study location and context:	7
5.4.2 The conceptual framework 177	7
5.4.3 Methods for data collection:	2
5.4.4 Data management and analysis	3
5.4.5 Ethics:	4
5.5 Results:	4
5.5.1 Characteristics of the interviewees:	4
5.5.2 Overall project timeline and staff involvement in ePMA:	5
5.5.3 Findings:	В
5.6 Discussion:	6
5.6.1 Key findings:	6
5.6.2 Implications for clinical practice:	8
5.6.3 Strengths and limitations of the work:	9
5.7 Conclusion:	9
Chapter 6: Economic impact of electronic prescribing use in secondary healthcare setting: a systematic review of the current literature 210	, D
6.1 Introduction:	С
6.1.1 Economic evaluation of technology in healthcare	1
6.1.2 Promoting technology in healthcare as a government policy214	4
6.2 Aims and objectives:	6
6.3 Methods	6
6.3.1 Criteria for selecting studies for this review:	7
6.3.2 Search methods	9
6.3.3 Data extraction:	C
6.3.4 Analysis	1

6.4 Results:	221
6.4.1 Search results:	221
6.4.2 Characteristics of studies included in the review:	223
6.4.3 Economic impact assessment	225
6.4.4 Quality assessment and limitations of the studies:	233
6.5 Discussion:	236
6.5.1 Summary of findings	236
6.5.2 Comparison of the review to previous reviews published in the literature	237
6.5.3 Implications for clinical practice:	238
6.5.4 Limitations for this review:	240
6.6 Conclusion:	240
Chapter 7 Overall thesis discussion	242
7.1 Overall discussion	242
7.1.1 The landscape of EP systems use in UK hospitals	242
7.1.2 Adoption of integrated ePMA systems	244
7.1.3 Expected benefits of EP use:	246
7.1.4 Issues to be considered when conducting HIT research and	
interpreting its findings:	247
7.1.4.1 The significance of HIT research context.	248
7.1.4.2 The complexity of HIT research context	248
7.2 A view of the future of EP in UK hospitals	250
7.3 Challenges of EP use in UK hospitals and implications on practice .	251
7.4 Strengths and limitations of this research	253
7.5 Future recommendations for practice and policy makers:	254
7.6 Further research endorsements:	257
7.7 Thesis conclusions:	257
References	259

Appendices272
Appendix A: The questionnaire used for the national survey of EP systems in English NHS hospitals272
Appendix B: The pre-notification letter used for the national survey of EP systems in English NHS hospitals:
Appendix C: The cover letter used for the national survey of EP systems in English NHS hospitals:
Appendix D: The follow up reminder letter used for the national survey of EP systems in English NHS hospitals:
Appendix E: Likelihood of interactions/overlap between systems (sites number: 36):
Appendix F: Invitation email- multiple EP systems study
Appendix G: Interview guide- Multiple EP systems study
Appendix H: Participant information leaflet- Multiple EP systems study . 293
Appendix I: Consent form- used for studies in chapter three and five 294
Appendix J: Detailed coding tree- multiple EP systems study
Appendix K: Sample of a framework matrix- multiple EP systems study 297
Appendix L: Interview guide- Implementation of integrated EHR study (chapter five)
Appendix M: Participant information leaflet- Implementation of integrated EHR study (chapter five)
Appendix N: Detailed coding tree- Implementation of integrated EHR study (chapter five)
Appendix O: Sample of a framework matrix- Implementation of integrated EHR study (chapter five)
Appendix P: The MEDLINE database search strategy- Chapter six 305

List of Figures

Figure 1 – 1: Overview of the research studies conducted through the
present thesis
Figure 1 - 2: A model depicting the complexity of prescribing processes: 25
Figure 1 - 3: Graduated levels of electronic prescribing
Figure 1 - 4: Overview timeline of the NIB framework milestones
Figure 2 - 1: Distributions of the survey respondents across England 63
Figure 2 - 2: Electronic prescribing (EP) systems use among respondent hospitals
Figure 2 - 3: Time since system deployment of all 125 unique system- hospital pairs (USHPs)70
Figure 2 - 4: Linkage of unique system-hospital pairs (USHPs) used for inpatient ($n = 32$) and discharge ($n = 71$) prescribing with pharmacy dispensing systems and other electronic systems
Figure 2 - 5: Decision support functionalities of unique system-hospital pairs (USHPs) used for inpatient (n = 32) and discharge (n = 71) prescribing74
Figure 2 - 5: Decision support functionalities of unique system-hospital pairs (USHPs) used for inpatient (n = 32) and discharge (n = 71) prescribing 74 Figure 2 - 6: Future plans for EP implementation in 101 respondent hospitals n=67
Figure 2 - 5: Decision support functionalities of unique system-hospital pairs (USHPs) used for inpatient (n = 32) and discharge (n = 71) prescribing74 Figure 2 - 6: Future plans for EP implementation in 101 respondent hospitals n=67
Figure 2 - 5: Decision support functionalities of unique system-hospital pairs (USHPs) used for inpatient (n = 32) and discharge (n = 71) prescribing74 Figure 2 - 6: Future plans for EP implementation in 101 respondent hospitals n=67
Figure 2 - 5: Decision support functionalities of unique system-hospital pairs (USHPs) used for inpatient (n = 32) and discharge (n = 71) prescribing74 Figure 2 - 6: Future plans for EP implementation in 101 respondent hospitals n=67
Figure 2 - 5: Decision support functionalities of unique system-hospital pairs (USHPs) used for inpatient (n = 32) and discharge (n = 71) prescribing74 Figure 2 - 6: Future plans for EP implementation in 101 respondent hospitals n=67
Figure 2 - 5: Decision support functionalities of unique system-hospital pairs (USHPs) used for inpatient (n = 32) and discharge (n = 71) prescribing74 Figure 2 - 6: Future plans for EP implementation in 101 respondent hospitals n=67
Figure 2 - 5: Decision support functionalities of unique system-hospital pairs (USHPs) used for inpatient (n = 32) and discharge (n = 71) prescribing74 Figure 2 - 6: Future plans for EP implementation in 101 respondent hospitals n=67

Figure 4 - 3: The structure of the system implementation governance at the
Trust
Figure 4 - 4: The 'Method M' project management model
Figure 4 - 5: Documents compiled by the ePMA working group 154
Figure 4 - 6: Mapping of the key themes identified in the present study 155
Figure 5 - 1: The context of the present case study 177
Figure 5 - 2: conceptual framework adapted from Greenhalgh et al (2008 a, b)
Figure 5 - 3: ePMA stakeholders tracking from project kick off until
December 2014
Figure 6 - 1: Prisma flow chart showing the screening and selection process

List of Tables

Table 1 - 1: Health Information Technology Frameworks 23
Table 2 - 1: Key information selected to meet the scope of the survey. 48
Table 2 - 2: Comparison of postal versus electronic surveys 52
Table 2 - 3: Methods implemented in the present study to improve the
response rate of the postal surveys and source of evidence
Table 2 - 4: Characteristics of responding versus non-responding trusts 64
Table 2 - 5: Number of respondent hospitals using electronic prescribing
systems (EP) at different stages of the patient pathway and with different
levels of organisational deployment68
Table 2 - 6: The most commonly used electronic prescribing systems among
respondent hospitals71
Table 2 - 7: Comments of respondents about hospital future plans to
introduce electronic prescribing systems
Table 3 - 1: Types of qualitative data analysis methods and considerations
for use in the current study91
Table 3 - 2: List of assumptions to determine Potential likelihood of
interactions/overlap between systems94
Table 3 - 3: Overview of the study sites, system characteristics and the
interviewees101
Table 5 - 1: Components of the diffusion of innovation model for complex
innovations in health services developed by Greenhalgh et al 174
Table 5 - 2: Characteristics of stakeholders interviewed in the case study 184
Table 5 - 3: Initial planned and actual dates of ePMA events and milestones
Table 6 - 1: Summary of the articles reporting economic outcomes directly
related to medication229
Table 6 -2: Summary of articles reporting economic outcomes related to
medications and other aspects of systems
Table 6 - 3: The quality assessment of the studies reporting economic
outcomes directly related to medication

Copyright material statement:

Copyright licence to reproduce third party material was obtained for the following:

1. Figure 1 - 2: A model depicting the complexity of prescribing processes

License Number	3884870436620
License date	Jun 09, 2016
Licensed content publisher	Oxford University Press

Permission to reproduce third party material was obtained for the following:

- 1. Figure 1 3: Graduated levels of electronic prescribing
- 2. Figure 1 4: Overview timeline of the NIB framework milestones
- 3. Figure 4 4: The 'Method M' project management model
- 4. Table 1 1: Health Information Technology Frameworks

5. Table 5 - 1: Components of the diffusion of innovation model for complex innovations in health services developed by Greenhalgh et al

Thesis overview:

The present thesis aimed to describe the landscape of electronic prescribing (EP) systems use in UK secondary care. The thesis chapters are built around three central themes:

- The uptake of EP systems in NHS hospitals.
- The potential challenges in relation to EP adoption which might face the NHS.
- The potential benefits of EP systems use.

An introduction about the thesis topic is presented in chapter one. The introduction includes definitions of EP, variations of EP systems as well as a review of potential benefits of EP systems in the literature. The history of EP systems deployment in the UK and comparisons of EP deployment elsewhere are then presented.

Chapters two - six present the core empirical work conducted throughout the researcher's degree. Chapter two presents a census of EP systems used in all acute NHS trusts. Unlike previous work in this area, the uptake and functionalities of all EP systems in respondent hospitals were captured, exposing for the first time the extent of multiple EP systems use within a single hospital. A qualitative study exploring the phenomenon of multiple EP system is presented in chapter three. There has been no previous study exploring multiple EP systems use in hospitals. Qualitative work in a UK NHS trust implementing a commercial electronic prescribing and medicines administration (ePMA) system integrated into an electronic health record (EHR) is reported in chapters four and five. Chapter six presents a

systematic review to assess the economic impact of EP systems use in hospitals.

The thesis ends with an overall discussion presented in chapter seven. The strengths and limitations of the overall research are highlighted and future research topics are identified. The figure below provides an overview of the research conducted throughout the present thesis (figure 1 -1).

Figure 1 – 1: Overview of the research studies conducted through the present thesis



EP: electronic prescribing, UK: United Kingdome, USA: United States of America

Chapter 1: Introduction

This chapter establishes grounding for the research conducted in the present thesis. The chapter starts with an introduction about technology use in healthcare. EP is then defined and the scope of use and the potential benefits of EP systems use are then presented. This section is then followed by a description of EP history in the UK along with comparison with EP use elsewhere. The chapter ends by providing conclusions and stating the aim and objectives of the present thesis.

1.1 Technology deployment in healthcare

Technology infiltrated into healthcare relatively late in comparison to other industries and professions (Bower, 2005). Healthcare was advancing and getting more complex. Hence, computerisation of healthcare delivery and automation of its processes were proposed as a solution to improve quality of care and to tackle this challenge. The drive behind this movement is improving quality of the care provided while maintaining cost effectiveness. Therefore, information technology initiatives top the health planning agenda worldwide (Centers for Medicare & Medicaid Services, 2013; NHS England, 2013; NHS England, 2015). Health information technology (HIT) is defined by the U.S. Department of Health and Human Services Office of the National Coordinator for Health Information Technology (HSS, ONC) as:

"The application of information processing involving both computer hardware and software that deals with the storage, retrieval, sharing, and use of health care information, data, and knowledge for communication and decision making."

(HSS, ONC, 2015)

The above definition of HIT suggests that it is a broad concept embracing various arrays of technologies which assist healthcare professionals to perform some of the manual tasks they perform during the course of patient care. Chaudhry et al (2006) developed analytical frameworks to describe the components involved with implementing HIT, types of HIT systems, and the functional capabilities of a comprehensive HIT system using expert opinions and a literature review (Table 1 - 1).

Deployment of HIT is complex and may vary between institutions. HIT systems can range from hospital wide integrated solutions which may be tailored to tackle all clinical and administrative matters to standalone applications or systems which might be working either in silo or linked (interfaced) in any form. Interfacing is a point of interaction that allows systems to function independently while communicating and/or sharing some information. As displayed in table 1 - 1, EHRs are one type of HIT systems. The frameworks developed by Chaudhry et al. consider EHR to be the foundation for a comprehensive HIT system (Chaudhry et al. 2006). EHR is a patient electronic record of health related information produced by encounters in a care setting. Many commercial EHRs are designed to combine data from large hospital services either through integration or interfacing with other systems. Examples of such systems are patient administration systems (PAS), picture archiving and communication systems (PACS) as well as EP systems. As EP is the focus of the present thesis, definitions of EP, variations of EP systems and their scope of use are detailed in the following sections.

Framework	Basis (Reference)	Elements
Components of an HIT implementation Types of HIT systems	Expert consensus Expert consensus	 Technological (e.g., system applications) Organizational process change (e.g., workflow redesign) Human factors (e.g., user-friendliness) Project management (e.g., achieving project milestones) Electronic health records Computerized provider order entry Decision support (stand-alone systems) Electronic results reporting (standalone systems) Electronic prescribing Consumer health informatics/patient decision support Mobile computing Telemedicine (data interchange- based)
		 Felemedicine (data interchange-based) Electronic health communication Administration Data exchange networks Knowledge retrieval systems HIT in general Other
Functional capabilities of an HIT system†	Institute of Medicine's "key capabilities" of an electronic health record**	 Clinical documentation (health information/ data) Results management Order entry management Decision support Electronic communication and connectivity Patient support Administrative processes Reporting and population health

Table 1 - 1: Health Information Technology Frameworks*

* HIT: health information technology.
† Assumes the electronic health record is the foundation for a comprehensive HIT system.
** Source of the functional capabilities if HIT systems developed by Chaudhry et al: Key Capabilities of an Electronic Health Record System. Washington, DC: Institute of Medicine, Committee on Data Standards for Patient Safety Board on Health Care Services; 2003.-

Source: Chaudhry et al. 2006

1.2 Electronic prescribing:

Medications are prescribed electronically in hospitals via EP systems which is the terminology often used in the UK or Computerised Provider (physician) Order Entry system (CPOE) which is the terminology used in the USA. In the UK, if an EP system allows recording of drug administration using an electronic medical administration chart (eMAR) then it will often be referred to as an ePMA system.

1.2.1 Definitions:

While there is no universally agreed definition for EP, definitions usually include, but are not limited to ordering or prescribing medication orders electronically. For example, in 2004 eHealth initiatives (EHI) defined EP as: 'The use of computing devices to enter, modify, review, and output or communicate drug prescriptions' (EHI, 2004)

The NHS Connecting for health (CfH) defined EP as:

'utilisation of electronic systems to facilitate and enhance the communication of a prescription or medicine order, aiding the choice, administration and supply of a medicine through knowledge and decision support and providing a robust audit trail for the entire medicines use'

(CfH, 2012)

As described in the earlier section, the term used instead of EP is CPOE in the USA. The fundamental difference between the above two terms is that the scope of CPOE extends to other types of medical orders such as requesting laboratory tests, X-rays, pathology tests and similar. The Health Information Management Systems Society (HIMSS) defines CPOE as:

'An order entry application specifically designed to assist practitioners in creating and managing medical orders for patient services or medications.

This application has special electronic signature, workflow, and rules engine functions that reduce or eliminate medical errors associated with physician ordering processes.

(HIMSS, 2013)

The Agency for Healthcare Research and Quality (AHRQ) defines CPOE as

'any system in which clinicians directly enter medication orders (and, increasingly, tests and procedures) into a computer system, which then transmits the order directly to the pharmacy'.

(AHRQ, 2014)

1.2.2 Scope and variations of EP systems

The complexity of prescribing was depicted in a model produced by Bell et al. (2004) (figure 1 - 2). The model shows that the act of prescribing includes processes not only related to prescribing but also processes related to transmitting and dispensing of prescriptions, administration of medicines as well as monitoring its effects. Moreover, it involves different healthcare professionals at different points of care. Consequently, EP systems are also complex. However, the model was based on an outpatient prescribing workflow in the US. Therefore, it might not be entirely applicable to the UK.





Source Bell et al. 2004

Cornford et al. (2009) established that the market of EP software in the UK is divided between four major types:

- Pharmacy based systems
- Clinical specialty-based systems (e.g. cancer systems, renal medicine and intensive care systems)
- Components or modules of larger hospital information system packages
- Home-grown software.

A more recent classification of commercial EP systems used in UK hospitals was developed and validated by Mozaffar et al (2014). The authors conducted a scoping review of the literature as well expert interviews with healthcare organisations, vendors and national EP experts to identify key systems and map their features (Mozaffar et al, 2014). Mozaffar and colleagues (2014) identified two broad categories of commercial systems used in the NHS, bespoke systems and packaged applications. Bespoke systems were defined as systems designed to meet particular needs of a single organisation. Conversely, packed applications were standard systems designed to meet requirements of different hospitals, which however, may be configured to meet certain requirements of a particular hospital. Mozaffar and colleagues (2014) divided packaged applications into four sub categories. These subcategories were standalone systems, modules within an integrated system, speciality systems and functionalities spread over several modules (Mozaffar et al, 2014). The classifications above establish that the term EP includes systems with a range of functions and may be potentially implemented in a wide range or organisational contexts. Moreover, systems may be procured commercially or developed in-house.

Generally, EP and CPOE systems vary in functionalities available. They can range from simple systems that allow basic prescribing to advanced systems that are integrated with computerised decision support systems (CDSS) which assist healthcare professional with decision making. EP systems could be standalone or integrated into EHR.

The authors of the EHR impact study classified six levels of EP, each of which includes and expands on the functionalities of the previous level (Figure 1 - 3) (Dobrev et al, 2008). The authors argue that the highest benefits are associated with the higher levels of EP as they offer improvements in the communication between patients, prescribers, pharmacists, and all other potential and actual stakeholders involved in the medicines management process (Dobrev et al, 2008).



Figure 1 - 3: Graduated levels of electronic prescribing

EMR: electronic medical records, MDs: doctor of medicine, PBM: pharmacy benefits mangers

Source: EHI, 2004 www.ehidc.org

1.2.3 Integrated systems versus 'best of breed' approach

In the 'best of breed' approach, institutions adopt systems or multiple software applications designed to be used for individual specialties or areas, allowing them to select the best niche system for each specialty. Each application is a standalone system, built on its own database and completely customised to meet the needs of its end-users (Hermann, 2010). One of the main advantages of this approach that little time will be required to set up and customise the systems as they are designed specifically for each speciality or area (Hermann, 2010). Moreover, implementation decision can be made within the department and the implementation process itself is arguably quicker than integrated systems implementation (Hermann, 2010). However, the difficulty of building and maintaining interfaces between multiple systems is a major drawback of best of breed approach.

As technology evolved, vendors developed integrated HIT systems that include all of the individual software applications or systems required to support all processes of a healthcare institution. Systems of an integrated solution are built using the same database. Therefore, there is no need to link other HIT systems and to translate data between systems. Moreover, the integrated solution allows maximum communication between various stakeholders involved in the medicines management process. The main disadvantages of integrated HIT systems are the limited choice of systems, costs, difficulty in systems implementation as well as the global effect of system customisation in healthcare institutions implementing the system (Hermann, 2010).

1.2.4 Potential benefits of EP use:

Policy makers seek evidence from the literature when constructing business cases to deploy HIT initiatives. Obtaining the evidence is fundamental to make informed decisions. It may also abolish any unrealistic expectations of end-users which may hinder the progress of implementation. Several reviews have examined the benefits of HIT including EP. A systematic review by Chaudhry et al in 2006 aimed to assess the impact of HIT on quality,

efficiency, and costs of medical care (Chaudhry et al. 2006). Increased adherence to guideline-based care, enhanced surveillance and monitoring, and decreased medication errors were the three major benefits on quality demonstrated in this review. The major efficiency benefit shown was decreased utilisation of care. Data on time utilisation as an efficiency measure were mixed. Empirical cost data were limited. The review identified gaps in the knowledge about commercially developed systems in community settings, organisational change, workflow redesign, human factors, and project management issues. A subsequent review by Goldzweig et al assessed costs and benefits of HIT (Goldzweig et al, 2009). The authors identified a proliferation of publications about health technology with little formal evaluation in this area. Data on costs and benefits were found to remain sparse. There were more articles published on commercial systems as well as patient focused standalone applications. A recent update by Buntin et al, showed more positive evidence emerging about HIT (Buntin et al, 2011). These authors used the methodologies of Chaudhry et al. (2006) and Goldzweig et al. (2009) to update their review covering the period 2007 to 2010. The majority of the recent articles on HIT (92%) were positive overall. The authors also found that the benefits of the technology were beginning to emerge in smaller practices and organisations.

A review of the effects of HIT on medicines management found that prescribing especially in hospital setting was comprehensively studied (AHRQ, 2011). The majority of the studies identified in this review showed that patient safety processes improved (52 of 60 studies) and errors were reduced (15 of 22 studies). EP was associated with time saving (related to the time taken to order or prescribe or the speed of the prescribing-toadministering processes) in half of the studies (4 of 7). Adherence to treatment guidelines, reminders, and recommended practice was improved in most of the studies (19 of 23). No quantitative data on workflows were found. However, issues of workflows were evident in very few qualitative studies. Black et al found EP to be the most studied intervention in all the systematic reviews included in their critical appraisal of the published reviews on e-health (Black et al, 2011). The authors found moderate evidence for improved organisational efficiency which was indicated by the increased productivity of pharmacists, decreased turnaround time, and more accurate communication between prescribers and pharmacy. Weak-to-moderate evidence was indicated for improved practitioner performance, increased ordering of corollary care, fewer medication errors, and more optimal prescribing leading to improved surrogate patient outcomes. However, there was far less evidence for improvements in patient outcomes. On the contrary, there was evidence of disruptions in workflow, opportunity costs for collaboration, introduction of risks to patient safety due to alert fatigue.

Several systematic reviews demonstrated limited evidence on the reduction of adverse drug events (ADEs) and /or error rates through the use of EP or CPOE systems (Wolfstadt et al, 2008; Ammenwerth et al, 2008; Reckmann et al, 2009; Rothschild, 2004). For instance, Wolfstadt, et al. (2008) conducted a systematic review to evaluate the effect of CPOE with CDSS on a range of ADEs in various clinical settings. Half of the ten studies identified in their review found a significant reduction in ADEs. None of the studies however employed randomised controlled trial (RCT) designs. Moreover, most of the studies (7 of the 10) evaluated home-grown systems. The weak study designs and heterogeneity of patient settings, outcome measures and systems evaluated prevented authors from reaching any definitive conclusion on effectiveness.

A systematic review of studies evaluating CPOE systems both without and with CDSS of varying degrees of complexity was conducted by Ammenwerth et al (2008). The authors included studies that employed controlled and before-after designs undertaken in a range of inpatient settings. Systems evaluated were home-grown and commercial systems. The authors found that most of the studies (23 of 27 studies) reported reduced rates of medication errors (effect size ranging from 13-99%). Moreover, most of the studies reporting on potential ADEs (6 of 8 studies) found a reduction in the incidence of this outcome (effect size ranging from 35-98%). Furthermore, two thirds of the studies reporting an actual ADE (4 of 6 studies) also found a significant reduction for potential ADEs. The authors highlighted the complexity of interpreting this body of evidence due to heterogeneity in study design and systems evaluated (Ammenweth et al 2008).

Reckmann et al. (2009) conducted a systymatic review to establish if CPOE systems reduce prescribing errors among hospital inpatients. The authors identified 13 papers (reporting 12 studies) published between 1998 and 2007. Of these, nine studies demonstrated a significant reduction in prescribing error rates for all or some drug types. However, several studies reported increases in duplicate orders and failures to discontinue drugs, often due to inappropriate selection from a dropdown menu or inability to view all active medication orders concurrently (Reckmann et al, 2009).

A review to evaluate the effects of CPOE on clinical and surrogate outcomes in patients hospitalised in general and critical care settings was conducted by Rothschild (2004). The author found three studies demonstrating reduction in medication errors and ADEs while one study failed to show any positive effects. The latter study evaluated CPOE use in a paediatric ICU setting.

On the whole, the reviews reported the benefits of EP demonstrated in the studies identified according to their criteria. The evidence was limited by the weak design of the studies as well as absence of defined terminology. Available quantitative research was limited and was done by a small number of institutions. Available financial and contextual data were limited. Systems were heterogeneous and sometimes incompletely described. In addition, generally data were not stratified according to the different variables such as intuition setting and type of technology used, which makes the interpretation of these findings challenging. Moreover, the lack of UK data makes extrapolating evidence to UK setting difficult.

1.3 UK EP History

Unlike secondary care, EP is well established in UK primary care (Cornford et al, 2009; Car et al, 2008). The electronic transmission of prescriptions from general practitioners (GPs) to pharmacies is common practice (Cornford et al, 2014). Hence, the UK is considered one of the most advanced nations in deployment of informatics in primary care worldwide (Cornford et al, 2014). The complexity of prescribing in hospitals and the diversity of different clinical specialty requirements may have been one of the barriers to implementation in secondary care (Car et al, 2008). The various EP initiatives and the courses of EP adoption over time in the context of UK hospitals are outlined in this section.

1.3.1 Pharmacy systems evolution

Technological innovations have been embedded early in UK secondary care. Around the 1980s, pathology systems as well as PAS systems became common place in UK hospitals (Goundrey-Smith, 2008). The use of pharmacy systems then spread in the mid-1980s following legislations requiring printed medicines labels as a replacement for of handwritten labels. Pharmacy systems were initially basic in function. Nevertheless they evolved over time in sophistication to support other functions such as stock control as well as the integrations of specialist modules to support preparations of total parenteral nutrition and intravenous additives. All the above mentioned systems were used in isolation in the relevant hospital departments (Goundrey-Smith, 2008). Arguably, they were therefore relatively easy to develop and implement. Pharmacy systems used in the UK have undergone dramatic developments after the new millennium such as linkage with pharmaceutical wholesaler procurement systems as well as the development of EP modules. Examples of these systems are JAC pharmacy system and Ascribe.

1.3.2 EP systems

The use of EP was perceived as the way forward for the NHS. The Wirral Hospitals and the Burton Hospitals were two of the earliest adopters of EP innovation in England (Cornford et al, 2009; Goundrey-Smith, 2008). Both centres introduced EP in the early 1990s (Gross 2002; Curtis and Ford

1997). In 2002, the Wirral hospitals achieved level 4 electronic patient record (EPR) status (Gross 2002). Generally, level 4 EPR includes not only EP but also offers advanced support such as embedded guidelines, rules, electronic alerts as well as access to knowledge databases. Anecdotal evidence showed that UK hospitals attempted to adopt EP systems. Several publications reported the evaluation of commercial or home-grown EP system piloted in specific clinical areas in UK hospitals (Fowlie et al, 2000; Nightingale et al, 2000; Gray and Smith, 2004 [as cited by Goundrey-Smith, 2008]; Franklin et al, 2007).

1.3.3 Cancer EP systems:

Adoption of cancer systems in the UK was a unique aspect of EP initiatives. Cancer networks, established in 2000, played a major role in driving up standards of care and improving outcomes for cancer patients (DoH, 2000a; Audit Commission, 2001; Macmillan cancer support, 2012). A total of 28 networks were created across England, each network consisting of a number of NHS trusts working together to deliver integrated cancer services to their local population. These networks received central funding from the government as well as funding from local NHS bodies (DoH, 2000a; Audit Commission, 2001; Macmillan cancer support, 2012). One of the initiatives of cancer networks was the introduction of departmental systems designed specifically for oncology/haematology clinic management. These systems were designed to manage the entire clinical pathway of patients including EP as well as dissemination of prescriptions for haematology and oncology patients (DoH, 2000a; Audit Commission, 2001). The systems also supported pathology test monitoring, protocol-based prescribing, post-cycle toxicity monitoring, pharmacy preparative functions (worksheets and labels) and documentation management. In addition, the systems enabled incorporating and monitoring of the UK wait after referral rules and helped terminate the postcode lottery (Audit Commission, 2001) and standardised care. Consequently, cancer systems may arguably be one of the most developed EP systems used in secondary care in terms of functionalities delivered.

1.3.4 Discharge systems:

Communication of medication changes upon discharge was another area where a lot of work was carried out to improve standards. A report by the Care Quality Commission (CQC) presented the results of a survey involving GPs covered by twelve primary care trusts (CQC, 2009a). The survey showed that 81% of practices reported incomplete or inaccurate medicine records in all or most patient discharge summaries received. CQC also developed a self-assessment tool for commissioners managing patients' medicines after discharge to identify how to commission safer services (CQC, 2009b). As an initiative to drive quality and safety, the percentage of discharge letters issued in accordance with national guideline standards, including information about medicines, was selected by the Department of Health (DoH) as one of the indicators for quality improvement in community services (DoH, 2011). A report published by the Royal Pharmaceutical Society (RPS) encouraged service providers (trusts) to incorporate the effective transfer of medicines information between secondary and primary care into the Commissioning for Quality and Innovation (CQUIN) payment framework (RPS, 2011). Therefore, there was an incentive for NHS trust to
adopt discharge EP systems to monitor and demonstrate the accuracy and completion of medicines' information transferred to GPs.

1.3.5 The NHS National Programme for IT

Moving healthcare towards a single electronic care record that connects all practices and hospitals in England was the main purpose of the national program for IT (NPfIT) which originated in 1998 (DoH, 2000b). The program was launched officially in 2002 and was overseen initially by the DoH. In 2005, the NPfIT program was led by CfH which was under the umbrella of the DoH. The NPfIT aimed to deliver an integrated care record solution including EP which could be accessed in both primary and secondary care, as well as a summary care record containing key medical information, such as allergies. The programme investment was estimated to be about £ 11.4 billion. The detailed care records systems were expected to be delivered to all NHS trusts and GP practices (excluding GP practices in the South) by the end of 2007, with increased functionality and integration until full implementation to be completed in 2010. However, deployment of systems lagged behind the intended CfH plans despite the expenditure (National Audit Office 2008; 2011). The delay in the delivery of the NPfIT in addition to its attributed costs was a matter of debate. In September 2011, the government announced dismantling the NPfIT which meant that trusts were left to make their own choices to procure EP systems and other technologies. In July 2013, the UK conservative government announced the NHS 'Safer Wards, Safer Hospitals Technology Fund' which involved a £1 billion investment in information technology (IT) over the following three years by the UK government and NHS organisations (NHS England, 2013).

Therefore NHS trusts were able to bid on awards to fund EP systems implementation.

1.3.6 The recent government IT strategy

In October 2014, a five year forward view to revolutionise the NHS was published (NHS England, 2014). The report acknowledged the drawbacks of the previous government IT strategy and proposed a new approach to achieve interoperability between NHS systems and services.

"In future we intend to take a different approach. Nationally we will focus on the key systems that provide the 'electronic glue' which enables different parts of the health service to work together. Other systems will be for the local NHS to decide upon and procure, provided they meet nationally specified interoperability and data standards."

(NHS England, 2014)

In November 2014, a policy paper was published by the national information

board (NIB) in the UK (NIB, 2014). The NIB is a new body under the DoH

which is responsible for developing the strategic priorities for data and

technology in health to deliver the maximum benefits. The paper describes a

comprehensive framework to transform data and technology use by 2020

(NIB, 2014). An overview of the NIB framework milestones and timelines is

presented in figure 1 - 4.

Figure 1 - 4: Overview timeline of the NIB framework milestones



GP: general practice, **NIB:** national information board, **HSCIC:** health & social care information centre, **CQC:** care quality commission, **HEE:** health education England, **SNOMED:** systematised nomenclature of medicine

Source: Personalised health care 2020, using data and technology to transform outcomes for patients and citizens. A framework for action, NIB, 2014

1.3.7 EP use elsewhere:

EP system adoption in hospitals started earlier in the USA than in the UK. The implementation of an EP system in the 1980s is documented in the literature (Tierney et al, 1993). Furthermore, most published studies of EP use originated in the USA. One of the most widely studied systems in the USA was developed at the Brigham and Women's hospital (Teich et al, 1992; Bates et al, 1998; Bates et al, 1999). The system's CPOE functionality was developed in the early 1990s and functionalities were enhanced in an upgrade to the system in 1996. The implementation of a commercial CPOE system in 2002 at the University of North Carolina hospitals was described by Spencer et al. (2005). Several evaluations of commercial CPOE system implementation were published in the literature (Mekhjian et al, 2002; Koppel et al, 2005).

Similar to the UK, the government and various bodies in the USA recognised the potential for EP systems therefore encouraged their use. The Institute of Medicine (IOM) produced two well publicised reports, which evaluated how technology could be used to support and improve patient safety (Kohn et al, 2000; IOM, 2000). Furthermore, in 2000, the Leapfrog Group, an independent, national not-for-profit organisation, endorsed CPOE as one of three changes that could most improve safety (Shapiro 2000). In 2000, the US government introduced capital funding available for the implementation of new HIT including EP systems (The Library of the US Congress, 2015). Further government legislation was developed to spread meaningful use of HIT through the Medicare and Medicaid incentive program (Centers for Medicare & Medicaid Services, 2013).

Despite the early uptake of EP in the USA, the service did not extend across all healthcare institutions. A recent US study reported that only 34% of US hospitals had CPOE for medication in 2010 (Pedersen et al., 2011).

EP use in primary care is well established in some European countries as opposed to secondary care (Kierkegaard, 2013). Denmark, Sweden and the Netherland have implemented national systems and are, therefore, ahead the rest of Europe in deployment of EP in primary care (Kierkegaard, 2013). Similar to the governmental initiatives in the UK and the USA, the European Commission have invested to drive HIT use in Europe forward. In 2012, the European Commission published the eHealth Action Plan aiming to achieve connected eHealth services in EU Member States (European Commission, 2015). The Action Plan focuses on developing common standards to enhance interoperable healthcare systems among member states including a cross border EP data exchange.

1.4 Conclusion:

In the UK, EP is widespread in the primary care setting (Car et al, 2008). The situation in secondary care seems to be different (Cornford et al, 2009). This could be explained by the bottom up approach of planning and implementation in primary care. Moreover, the services provided in primary care are usually less complicated than in hospital setting.

Variations of EP initiatives in the UK have influenced the types of EP systems used in secondary care. In UK secondary care, adopting HIT began in the early 1980s and the first reported use of EP was in early 1990s. At that point, the adoption approach was generally bottom up which meant that trusts initiated and selected what system to implement. EP systems that facilitate several parts of the medicines use process were implemented in some hospitals (Cornford et al, 2009). Commercial and/or home-grown systems were used in a few UK trusts. Furthermore, the addition of EP modules to pharmacy systems may have increased the use of EP in UK hospitals to some extent.

EP adoption in specific areas or for specific part of the medicine use process was driven by local and governmental initiatives due to other priorities and agendas. Some hospitals implemented EP systems which only facilitate one part of the medicines use process (Cornford et al, 2009). A typical example of such systems is discharge EP systems. There were also speciality systems implemented and used in specific clinical areas such as in oncology or critical care (Cornford et al, 2009).

In early 2000, the government started a top down strategy through the NPfIT which aimed to deliver an integrated solution nationally. The program was dismantled and the new UK government re-established the bottom up approach and offered financial incentives for NHS trusts to adopt EP systems and other technology.

1.5 Thesis aim and objectives:

The aim of the present thesis is to describe the landscape of EP systems use in UK hospitals.

The objectives were:

- To report the uptake of EP and variations of systems in English acute and foundation NHS Trusts (chapter two).
- To further explore the phenomenon of multiple EP systems which emerged through the findings of the national survey of EP systems in English acute and foundation trusts (chapter 3).
- To examine the process and complexity of a commercial integrated ePMA system implementation in an NHS trust (chapter 4, 5).
- To identify the economic impact of EP implementation in the secondary care setting (chapter 6).

Chapter 2: National survey of electronic prescribing systems in English acute and foundation NHS Trusts

2.1 Introduction:

The synthesis of EP history in the UK and the variations between EP systems as well as changes in government policy raised a question about the extent of EP deployment in NHS hospitals (chapter one). Hence, a national census of EP system's use and variations in all acute and foundation English NHS trusts is presented in the present chapter.

Studies have reported prescribing errors in 8.9 to 14.7% of inpatient medication orders in English hospitals (Dornan et al, 2009; Franklin et al, 2011; Seden et al, 2013). The use of EP is advocated as a potential solution to improve patient safety as well as efficiency (Kohn et al, 2000; DoH, 2000; PriceWaterhouseCooper, 2013). EP use is widespread in primary care in the UK with various degrees of sophistication (Car et al, 2008). However, little is known about the utilisation of EP systems in secondary care and it is reported that EP utilisation may be less prevalent than primary care (Cornford et al, 2009). An informal survey was carried out in the new millennium to establish the level of EP adoption in hospitals in the UK (Summers, 2000). At that time, only one in ten hospitals had an EP system in place. However, a sizeable majority of hospitals had plans to implement a system, or were potentially discussing the introduction of a system in the future. Attitudes towards EP adoption in the US were captured in the Modern Healthcare's 2003 survey (Morrissey, 2003). Two thirds of respondents in US hospitals which had no EP had no intention of acquiring EP within the following year. Of these, more than half reported that resistance of physicians to use these systems was the main barrier to implementation. Another barrier reported was the financial implications of system procurement on health institutions. Some reported that there were more economical alternative measures to monitor and alert clinicians to errors.

A survey of the attendees of the 2010 National EP Forum in the UK showed that 82% of the 56 Trusts represented at the Forum which responded to the questionnaire were either 'thinking of implementing' or 'currently implementing' an EP system (Crowe et al, 2010). A more recent paper reported on experiences of EP implementation based on a survey of EP conference attendees representing 55 (33%) of English NHS hospital trusts (Cresswell et al, 2013). However, these were convenience samples and unlikely to be more widely generalisable. Specifically, the findings of these studies may overestimate the prevalence of EP as the attendees of these events are likely to be representatives of trusts currently using or planning to implement EP in the future.

As described previously in chapter one, there was a strong governmental drive to spread the adoption and usage of EP in healthcare nationally within England. As the NPfIT ran for nearly a decade before it was dismantled in 2011 (National Audit Office, 2008; National Audit Office, 2011), it might be expected that the programme brought many changes to the way technology was used within the NHS including EP systems. Evaluation of these initiatives' consequences is vital for any meaningful assessment or effective planning of EP system adoption in England. A comprehensive formal evaluation of HIT deployment was carried out during the NPfIT. However, at that time the technology was not ready to be evaluated (Cresswell et al, 2011). Therefore, the extent to which EP systems are used in England represents a significant gap in knowledge. This chapter describes a survey study of EP systems in England which was designed and conducted in 2011 to address this significant knowledge gap.

2.2 Aim and objectives:

The aim of this national survey was to ascertain and report the uptake of EP systems in English acute and foundation NHS Trusts.

The objectives of the study were:

- To establish the prevalence and types of EP systems used.
- To capture how widely systems are used in each trust.
- To explore the functionalities of the identified EP systems.
- To capture data about sites with multiple operational EP systems.
- To explore the prescribing of specific drugs which are known to be challenging to be prescribed via electronic systems and assess the need to use supplementary drug charts simultaneously to ensure safe prescribing.
- To capture the future plans of trusts for adopting EP systems and the potential timeframe of these changes.

2.3 Methodology:

The following section describes the methodological considerations when defining the scope of the work and planning this study. Aspects related to survey and sample design, approach to the questionnaire and methods to maximise response rate are presented in this section. The specific methods used are detailed in a subsequent section.

2.3.1 Scope of the survey:

The scope of the survey was defined by ZA and PhD supervisors (NB and BDF). This was built on previous work in this area (Summers, 2000) but was also expanded and shaped by prior field work done by ZA (Chapter 4) and the supervisors' experience in this field. The areas of interest identified as the scope of this survey were:

- The types, numbers and variations of EP systems used in NHS hospitals.
- Functionalities of the EP systems and comprehensiveness of prescribing of drugs.
- The clinical pathways in which these EP systems were used.
- Future plans for EP system introduction and/or change in trusts.

In order to guide the survey and questionnaire design, key information for data collection was selected to meet the survey scope (Table 2 - 1).

Demographic data	Number of acute hospitals in the trust	
	Site selected for the survey:	
	 Number of wards 	
	 Type of patient population 	
	 Use of EP (yes/no), if yes number of 	
_	systems	
Details about EP	Use of EP and total number of systems available	
systems	List of information collected for each system:	
	 Name of system 	
	 Time since deployment 	
	 Type of prescribing 	
	(inpatient/discharge/other)	
	 Clinical areas (wards) where the system 	
	is used.	
	 System type and features: 	
	Commercial vs in-house	
	 Interfaces with pharmacy and 	
	other hospital systems	
	 Clinical decision support features 	
	Prescribing of CIVI,	
	corticosteroids, warfarin, and	
	tapering doses as well as use of	
	supplementary drug charts.	
Future systems	Plans to introduce any EP system/s	
-	Suggested timeframe	

Table 2 - 1: Key information selected to meet the scope of the survey.

EP: electronic prescribing CIVI: continuous IV infusions

2.3.2 Survey and sample design:

Census and sample surveys are two methods that could have been used to collect data. A census survey involves approaching all members of a given population while a smaller part of a population will be selected for a sample survey. Although census surveys are costly and labour intensive, they offer the advantage of gathering more comprehensive information assuming a satisfactory response rate. Moreover, a census is not subject to sampling errors which is one of the major drawbacks of a sample surveys. On the

other hand, sample surveys are more convenient, less costly and less labour intensive. This survey aimed to measure the extent of EP use in NHS hospitals. The study population is not prohibitively large and it is likely to be quite diverse. Therefore a census approach was considered desirable and appropriate.

2.3.2.1 Population:

Following government devolution in the UK, each of the four countries (England, Scotland, Wales and Northern Island) has governed its' own healthcare system. This resulted in differences in healthcare systems governance, structure and funding across the UK (Bevan et al, 2014). Therefore it was decided to focus on England in this present study. Most of healthcare system is delivered by the NHS in England. Therefore the target population was defined as all acute and foundation NHS trusts. Trusts may or may not have more than one acute hospital. Surveying all acute hospitals within a trust would have been ideal. However, this would have increased the respondent burden therefore might have influenced the response rate of the survey. Instead, the survey population was defined as the main acute hospital of each trust as we assumed the main hospital would potentially depict a representative picture of EP acquisition in a trust.

2.3.2.2 Target respondents:

EP prescribing systems are managed and used by different clinical and nonclinical staff. These include doctors, nurses, pharmacists, IT staff and other allied healthcare professionals such as physiotherapists. Surveying representatives of each staff group would have been ideal. However, this was deemed impractical. Completing the survey required a broad knowledge of existing systems within the hospital as well as some working experience as a user. Therefore clinical staff working across various clinical areas and who use or access EP system/s are ideal. Therefore, pharmacists were selected as the target participants for the survey.

2.3.2.3 Approach to the survey:

Broadly, survey questionnaires can be self or researcher-administered. Selfadministered questionnaires could be done on paper (either via post or group administration) or electronically (via email or web). There are various advantages to self-administered questionnaires. The first advantage is convenience for both researchers and participants. Researchers can cover a wide geographical area in a relatively short period of time. Also, participants can complete the questionnaires at their own pace and are able to obtain more information from colleagues if necessary. Second, self-administered questionnaires are cheaper to administer than researcher-administered questionnaires particularly if travel costs are required. Finally, selfadministered questionnaires minimise interviewers' bias effects. On the other hand, participants' responses rely on their own interpretation of the questions and there is little opportunity to seek clarifications from the researcher as with researcher administered questionnaires. This can be minimised by careful phrasing of the survey questions and extensive piloting of the questionnaire. A self-administered questionnaire was deemed the most appropriate choice for this census. Methods used to address potential disadvantages of this approach are explained in later sections.

Paper vs. electronic surveys:

Careful consideration was given to the mode of sending out the questionnaire. Post and online tools such as SurveyMonkey and Qualtrics survey software were both considered. Each mode of sending the questionnaire was costed and the potential pros and cons explored. On the whole, electronic surveys were found to be cheaper and more convenient for both the researcher and the respondent. However, few process related concerns were raised which were related to obtaining personal email addresses of respondents as well as security filters on the NHS. Moreover, evidence suggests that healthcare professionals are more likely to respond to postal surveys than electronic surveys (Scott et al, 2011). A summary of the evaluation is detailed in table 2 - 2.

Despite the user friendliness and cost effectiveness of online administered questionnaires, the use of postal survey was considered to be more appropriate for various reasons. The main reason was to avoid the risk of blocking the survey link by the NHS security filters. Furthermore, to save the time and efforts required to obtain the personal emails of all potential participants.

Table 2 - 2: Comparison of postal versus electronic surveys

Factors	Postal survey	Electronic survey
Response rate	Higher than electronic surveys.	Lower than postal surveys (Couper and Miller 2009; Scott et al, 2011; VanGeest et al, 2007)
Process preparation time (researchers)	Labour intensive as time will be spent on printing, franking and personalising letters.	Relatively faster as a mail merge could be used to personalise the emails. However, the questionnaire has to be designed using the tool.
Address (researchers)	The postal address can be obtained from the NHS choices website	Obtaining personal email addresses would be required
Completion (respondents)	Easy to complete and doesn't require access to a computer or internet therefore could be completed anytime.	A link will be provided via the email to be completed online. However, this might be blocked by the NHS security filters.
Information security	Risk of postal loss	Information held on secure web-based software
Question design	Flexible	Restricted by the tool used. Some degree of customisation is available.
Data management	No support	Support available ¹ via the tool
Costing	Total cost approximately £338.23* Paper (165 sites, 6 pages) £7.59 Printing (165 @0.024 per 6 pages) £7.92 Envelopes (165 trusts @ 0.161 each) £26.56 Franking (165 trusts @ 0.4 for second class) £66.00 Return Envelopes (165 trusts @ 0.161 each) £26.56 Franking (165 trusts @ 0.4 for second class) £66.00 Follow up via post (assuming a response rate of 30) total cost 137.669	Total cost approximately £220 SurveyMonkey subscription ("Annual Select" package 12-month plan)£204.00 Telephone calls for obtaining addresses (165 trusts @ 2p/min for 5 mins) £16.60

Cost based on data from Office Depot® and Royal Mail website: http://www.royalmail.com/

¹ SurveyMonkey offers analysis tools that allow researchers to view, analyse, and export results as well as view data trends at any stage of the study.

2.3.3 Approach to the questionnaire:

2.3.3.1 Questions:

Selection of the type of questions is vital to gather reliable information in an effective manner. There are two main types of questions and each has their own pros and cons (Bryman, 2001). The first type is open ended questions which allow participants to give unrestrained responses. Open ended questions are useful for collecting rich and novel information therefore are more suitable for interviews. The downside of open ended questions is that analysis would have been more difficult as data are not uniform (Bryman, 2001). The second type is closed questions. Examples of this type are 'yes' and' no' questions, 'true' and 'false' questions, scaled questions and multiple choice questions. Closed questions are convenient and easy to analyse (Bryman, 2001). They are suitable for collecting factual information like age or marital status for example and assessing opinions through a rating scale. However, they may limit the range of answers that participants may provide.

A mixture of the above two question types could be used. An example would be when categorised responses are provided including 'other' category which allows respondents to record different responses. Similar to closed questions, they are completed quickly by participants and are easier to record and analyse than open ended questions.

Given the factual nature of the information collected and the targeted population, it was decided to use closed questions. To prevent limiting respondents' answers, they were given the opportunity to elaborate on each answer they selected in a comments section provided following each question. Furthermore, two categories 'not applicable' and 'not sure' were included in the answers options to encourage participants to complete all the questions without having to select potentially inappropriate responses.

2.3.3.2 Questionnaire layout:

Questions were arranged into broad thematic categories: background about the trust and the selected hospitals, information about the systems, and information about the participant. Filter options and skip patterns were used to ask respondents about the appropriate information and save their time. For example, if a participant selected that they did not have an EP system at their hospital they would skip all the detailed questions about systems. Whenever appropriate, questions were presented in a matrix format. The matrix included a series of question under a common theme with similar answer choices. This was preceded by a phrase explaining what is required from respondents to answer and illustrated examples were given where applicable. This format was used to ensure the questionnaire was as short as possible and to make it easier for participants to respond.

2.3.4 Methods to maximise the response rate:

Methods to increase the response rate of postal surveys were explored. Several systematic reviews of this topic were identified (Edwards et. al, 2002; Nakash et. al, 2006; Edwards et. al, 2009). Edwards and colleagues conducted a systematic review of RCTs of any method used to influence response to postal questionnaires (Edwards et. al, 2002). They found that chance of response was more than doubled when a monetary incentive was used (odds ratio (OR) 2.02; 95% confidence interval (CI) 1.79 to 2.27) and when incentives were not conditional on response (OR 1.71; 95% CI 1.29 to 2.26). They also found that response rates were higher when (1) short questionnaires¹ were used (OR 1.86; 95% CI 1.55 to 2.24), (2) personalised questionnaires and letters were used (OR 1.16; 95% CI 1.06 to 1.28), (3) coloured ink was used (OR 1.39; 95% CI 1.16 to 1.67) (4) the questionnaires were sent by recorded delivery (OR 2.21; 95% CI 1.51 to 3.25), (5) stamped return envelopes were provided (OR 1.26; 95% CI 1.13 to 1.41), and (6) questionnaires were sent by first class post (OR 1.12; 95% CI 1.02 to 1.23). In addition, contacting participants before sending questionnaires was found to increase response (OR 1.54; 95% CI 1.24 to 1.92), as well as follow up contact (OR 1.44; 95% CI 1.22 to 1.70) and providing non-respondents with a second copy of the questionnaire (OR1.41; 95% CI 1.02 to 1.94).

Nakash and colleagues conducted a systematic review to assess methods of increasing response to postal questionnaires specifically in healthcare studies (Nakash et. al, 2006). Authors found that reminder letters and telephone contact had the most significant effect on response rates (OR 3.7, 95% CI 2.30 to 5.97 p = or <0.00001). Shorter questionnaires also improved response rates to a lesser degree (OR 1.4, 95% CI 1.19 to 1.54). However

¹ Length of the questionnaires varied between trials, some compared one page with a two page, and others compared four or more pages with longer alternatives.

authors found no evidence that incentives, re-ordering of questions or including an information brochure with the questionnaire conferred any additional advantage.

Edwards and colleagues updated their earlier review in 2009 and explored methods to increase response to both postal and electronic questionnaires (Edwards et. al, 2009). A total of 481 trials related to postal questionnaires were eligible evaluating a total of 110 methods to improve response rate. However, results of the trials identified were very heterogonous. In addition to the methods found in their original review, Edwards and colleagues identified further methods associated with higher response rate. These were: (1) a teaser on the envelope - e.g. a comment suggesting to participants that they may benefit if they open it (OR 3.08; 95% CI 1.27 to 7.44), (2) a more interesting questionnaire¹ topic (OR 2.00; 95% CI 1.32 to 3.04; heterogeneity P = 0.06), (3) mentioning an obligation to respond (OR 1.61; 95% CI 1.16 to 2.22; heterogeneity P = 0.98), (4) university sponsorship (OR 1.32; 95% CI 1.13 to 1.54; heterogeneity P < 0.00001), (5) non-monetary incentives (OR 1.15; 95% CI 1.08 to 1.22; heterogeneity P < 0.00001), and (6) an assurance of confidentiality (OR 1.33; 95% CI 1.24 to 1.42). Methods selected to improve response rate in the present study are described in table 2 - 3.

¹ Example of more interesting questionnaire topic is asking questions particularly relevant to the study participants.

Table 2 - 3: Methods implemented in the present study to improve the response rate of the postal surveys and source of evidence.

Methods	Edwards et al, 2002	Edwards et al, 2009	Nakash et al, 2006
Pre-notification letters	+	+	
Personalised questionnaires and letters (Handwritten address on envelopes)	+	+	
Using coloured ink and good quality paper	+		
Original signatures on cover letter	+	+	
Return envelopes	+	+	
Incentives non-monetary		+	
Follow up contact	+	+	+
Providing a second copy of the questionnaire.	+	+	
University sponsorship/association		+	
Assurance of confidentiality		+	

+ Evidence shows positive effect on the response rate of postal surveys.

2.4 Methods:

A cross-sectional descriptive census of acute and foundation NHS trusts in England was conducted in 2011. This census was a joint work with another PhD student who explored medication administration and distribution systems in English NHS hospitals. Only those aspects related to EP systems have been presented in this thesis.

2.4.1 Study population:

A list of all acute and foundation trusts in England was obtained from NHS Choices (NHS choices, 2011). Community trusts were excluded as they were out of the scope of the survey. All speciality and tertiary care trusts were included. A total of 165 trusts were therefore eligible for inclusion. When trusts had more than one hospital, respondents were requested to select the main acute hospital of the trust.

2.4.1.1 Participants:

The targeted participants for this survey were chief pharmacists (CPs) of selected trusts. CPs were encouraged to delegate the questionnaire to colleagues who had the necessary experience if they were not able to complete it themselves.

2.4.2 Questionnaire development:

A self-administered questionnaire was developed for the purpose of this census taking into account the literature around EP and the expertise of the research team. The questionnaire was developed according to established good practice (Kelley et al, 2003) and to all the methodological considerations described in earlier sections.

2.4.2.1 Questionnaire content:

The final version of the questionnaire can be found in appendix A. The questionnaire was composed of two parts. Section A of part one, and part two, are the relevant elements of the questionnaire to the present thesis. Section B of part one was related to the other PhD student. Section A of part one included six questions developed to capture the trust's demographics. Part two included twelve questions about the EP systems and information about the respondents' role, contact details as well as consent for participating in further related work in the future. Questions 20, 25, 26 (a-d), 27 (a, b, d, e, h, i) were adapted from a previously developed tool (Summers,

2000) and tailored for the purpose of this survey. The rest of the questions were developed by ZA, incorporating discussions with both PhD supervisors. Specific questions exploring the extent to which systems could be used to prescribe warfarin, continuous intravenous infusions (CIVIs), insulin, and drugs which require a tapering dose were included, as these were reported to be challenging to prescribe electronically (Cresswell et. al, 2013). The working definition of EP was any form of EP operational in at least one ward or clinical area.

2.4.2.2 Questionnaire pilot:

The questionnaire was drafted by the researcher (ZA) then reviewed by ZA and two PhD supervisors (BDF, NB) to ensure clarity of questions. Several iterations of the questionnaire were then piloted informally with colleagues to eliminate ambiguous questions. After rigorous modification of the survey questions, a pilot study was carried out with version eight of the questionnaire. Piloting was done by observing respondents while completing the questionnaire. The observing researcher (ZA or the other PhD student) was available to respond to any clarifications the respondents might have. They also discussed the process of completing the questionnaire with respondents and obtained feedback. The aim of the pilot study was to exclude the possibility of misinterpretation of the questions and ensure coverage of main relevant issues related to EP use in hospital settings. The two researchers piloted the questionnaire with fifteen pharmacists with variable work experience and specialty from across four trusts. The pharmacists also had variable work experiences with EP systems.

2.4.3 Survey implementation strategy

A pre-notification letter (Appendix B) was sent three weeks in advance of the survey. The questionnaire was distributed along with a cover letter and a Freepost return envelope to all 165 trusts on 1 July 2011 (Appendix C). A follow up reminder letter was circulated to all non-responders 4 weeks later (Appendix D). A second electronic reminder was sent to non-responders with available email addresses in October 2011. All letters were personalised and signed by hand. The covering letter stated that all responses would remain confidential and anonymised. However, respondents were asked to provide their names and contact details if they were willing to be contacted again for clarifications or future research.

2.4.4 Management of survey responses:

2.4.4.1 Data entry and cleaning:

Excel 2007 was used for data entry and descriptive analysis. Minitab 16.2.2 was used to compare characteristics of respondents and non-respondent trusts. A random sample of 20% of the questionnaire data entry was cross-checked by the other PhD student.

Any unclear responses were reviewed by one of the PhD supervisors and a joint decision was made on interpretation. The majority of these were unclear handwriting and some vague comments. Missing responses about the trusts demographic were obtained from each trust's website if possible. Missing data from questions 20 and 21 (questions about availability and number of EP systems) were refilled according to the responses in the following questions whenever possible. For example, in one questionnaire,

the number of EP systems reported was incorrect (number was less than actual number of systems filled in the rest of questionnaire). The wrong entry was corrected to match the responses completed in the rest of the questionnaire. In two questionnaires, respondents gave a range instead of a number which was corrected to match their response in the subsequent questions.

A total of 25 responders were then contacted either electronically or via telephone to clarify some the answers or request further information about the systems. Information on commercial systems was also checked against supplier websites and a database of NHS information technology as the same system was sometimes referred to by different names (eHealth Insider Intelligence, 2012).

2.4.4.1 Data analysis:

Systems used solely for clinical decision support for dosing (but not prescribing) specific drugs, such as oral anti-coagulants, were excluded from analysis. Similarly, reported future EP systems, which are systems yet to be implemented, were excluded from the analysis.

EP systems were subdivided based on the stage(s) of the patient pathway in which they were used (inpatient, discharge and/or outpatient), and their characteristics described. A system used in all adult medical and surgical wards was considered to be hospital-wide (or in the case of paediatric hospitals, all paediatric medical and surgical wards); this was because even hospitals with extensive use of EP may have one or more clinical areas, such as critical care or the emergency department, where EP is not used. As individual commercial systems were used differently in different settings, analysis was performed by hospital, and by unique system-hospital pair (USHP). The latter was defined as one EP system implemented in one hospital. Therefore the same commercial EP system in two different hospitals was counted as two USHPs. Similarly, one hospital with two EP systems would also count as two USHPs

2.4.5 Ethics

A study brief was submitted to the Joint Research Office at Imperial College London and Imperial College Healthcare NHS Trust. The work was classified as service evaluation therefore was exempted from obtaining an NHS ethics approval. University ethics approval was granted from the School of Pharmacy ethics committee (now UCL School of Pharmacy).

2.5 Results:

2.5.1 Respondent characteristics

2.5.1.1 Sites:

One hundred and one of the surveyed 165 hospitals responded (61%); of which 56 were foundation trusts. Nearly two thirds of respondents (56%, n=57) returned the questionnaire after the first contact and the remaining 44% (n=44) replied after follow up. Figure 2 - 1 illustrates a map showing the distribution of the survey respondents across the country.

Figure 2 - 1: Distributions of the survey respondents across England



Two questionnaires were completed on behalf of all the hospitals within a trust; one for five sites and one for two sites. The rest chose the main acute hospital as instructed.

The majority of responding hospitals provided services for both paediatric and adult patients (86%, n=87). Nearly 13% (n=13) of the hospitals treated an adult population exclusively. Only one paediatric speciality hospital responded to this survey (0.9%). The number of hospital wards ranged between three and 65 (median: 25 wards). A total of twenty respondents reported number of hospital beds instead (n=10) or did not complete this section (n=10). Therefore information was obtained from the trust website. Overall, there were no significant statistical differences identified between respondent and non-respondent trusts in numbers of acute hospitals, number of wards at the main acute site, or types of service provided (Table 2 - 4).

Characteristics	Respondents	Non-respondents*	Statistical
	(n=101 trusts)	(n = 64 trusts)	analysis
Median number			n-0.08 [.]
of acute	1 (1 - 5)	1 (1-5)	Mann-
hospitals in trust		r (1- 5)	
(range)			whithey test
Median number			n-0.12 [.]
of wards at main	25 (3-65)	22 (1 44)	μ=0.12, Μορρ
acute hospital		23 (1- 44)	
(range)			whithey test
	Adults (n=13) or	Adults (n=2) or	p=0.35;
Services	paediatrics (n=1)	paediatrics (n=3)	chi square
provided by main	only: 14 (14%)	only: 5 (8%)	test with
acute hospital			Yates
	Mixed: 87 (86%)	Mixed: 59 (92%)	correction

 Table 2 - 4: Characteristics of responding versus non-responding trusts

* Data obtained from the trust websites

2.5.1.2 Participants:

Pharmacists in higher managerial roles (CPs, associate CPs, assistant CPs, pharmacy directors and other managers) represented 60% (n=61) of the respondents. Nearly a third (32%, n=32) of the questionnaires were completed by other senior pharmacists, mainly medication safety, pharmacy governance or EP leads. One questionnaire was completed by a pharmacy

technician manager and one by a nurse. The remaining 6% (n=6) of responders were unknown. The majority of respondents (89%, n=90) gave consent to be contacted for any follow up or future research.

2.5.2 Prevalence of EP use

Figure 2 - 2 shows the level of EP use among respondents. Slightly more than two thirds (n=70) of the sites had at least one form of EP at the point of this survey. More than half of sites with EP had more than one system in place (55.7%). Twenty seven sites had two EP systems, ten had three systems and two had more than three systems.

Figure 2 - 2: Electronic prescribing (EP) systems use among respondent hospitals.

Numbers in brackets refer to percentages of the total in the previous box.



2.5.3 Stages of the patient pathway and extent of organisational deployment

The most common use of EP systems was for discharge prescribing only (Table 2 - 5). Nearly half of all respondent hospitals (48%, n=48) reported systems used solely for discharge with or without other EP system/s. A total of 55 systems were reported by the 48 hospitals (Table 2 - 5). In most cases these were specialist discharge prescribing systems, but in some hospitals, commercially available systems that could also be used for inpatient prescribing were being used solely for discharge. Some hospitals had multiple discharge systems used in different clinical areas.

Specialist chemotherapy EP systems were the second most common. Chemotherapy systems were used in 34 (34%) of respondent hospitals (Table 2 - 5). Two hospitals each had two different chemotherapy systems in operation at that time. In addition, sixteen other specialist inpatient systems were used across 15 respondent hospitals. Systems were most commonly used in adult critical care.

General inpatient prescribing was less common. Only 13 (13%) respondents reported hospital-wide inpatient prescribing. All 13 systems were also used for discharge prescribing, four were also used for prescribing in intensive care and only one was reported to be used in outpatients.

Table 2 - 5: Number of respondent hospitals using electronicprescribing systems (EP) at different stages of the patient pathway andwith different levels of organisational deployment.

Type of prescribing	Number of hospitals (% of 101 respondents)	Comments		
Generalist inpatient pres	cribing systems			
Generalist inpatient prescribing system in all adult medical and surgical wards (+/- other clinical areas) Generalist inpatient	13 (13%)	 All 13 also used for discharge prescribing One also used in outpatients 4 also used in adult critical care All 3 also used for 		
prescribing system in	3 (3%)	discharge prescribing in		
Some cillical aleas	rany innationt n			
Adult critical care 11 (11%)				
Paediatric critical care	1 (1%)			
Neonatal care	1 (1%)			
Renal	3 (3%)			
Specialist chemotherapy	prescribing sys	tems		
Prescribing of chemotherapy only	34 (34%)	 36 systems used across 34 hospitals 12 used for inpatients and at discharge 17 used in inpatients alone 3 used at discharge alone 4 used only for daycase chemotherapy 		
Discharge prescribing	Γ			
Standalone discharge prescribing system	48 (48%)	 55 systems used across 48 hospitals 40 used on all adult medical and surgical wards 15 used on specific ward(s) only 		
Outpatient prescribing				
Standalone outpatient prescribing system	2 (2%)	 1 hospital-wide outpatient system 1 system used in the emergency department only 		

Each EP system could be used in more than one stage of the patient pathway (e.g, inpatient and discharge), and some hospitals had more than one system. Numbers therefore do not add to 100%.

2.5.4 EP systems:

A total of 60 different systems were operational across respondent hospitals. These systems varied in type, utility and supplier. There were a total of 125 USHPs. Twenty four systems were developed 'in-house', representing 40% of systems and 19% of USHPs. Three of these were reported to be the product of joint collaboration between the relevant trust and a commercial vendor. Out of these, only one was reported to be a bespoke commercial system. This was a system conceived a long time ago by the trust and then handed over for further development to a commercial vendor. The remainder were commercial EP systems.

2.5.4.1 Time since systems deployment:

Figure 2 - 3 demonstrates the time since deployment of all 125 USHPs at the point of the survey. Seventeen USHPs (14%) had been in use for less than a year, while 29 USHPs (23%) were used for more than a year but less than two years. Slightly more than a third of all USHPs (35%, n=44) were in place between two to five years. Thirty three USHPs (26%) had been used for more than five years.

Figure 2 - 3: Time since system deployment of all 125 unique systemhospital pairs (USHPs).



2.5.4.2 Most commonly used systems:

Two specialist cancer care systems were the most commonly used (ChemoCare and Aria), followed by a commercially available discharge system (Sunquest ICE). Another commercially available system (JAC) which can be used for inpatient, discharge and/or outpatient prescribing was the third commonly used, followed by a specialist system used for critical care (Metavision). In some cases the same commercial system was used differently in different hospitals. For example, one such system was used hospital-wide for discharge prescribing in two hospitals, and for both inpatient and discharge prescribing on specific wards in another five hospitals. Table 2 - 6 shows the most commonly reported systems in the survey.

	Number of USHPs (Percentage of all
System Name	USHPs)
Chemocare	21 (16.8%)
ARIA	9 (7.2%)
ICE	9 (7.2%)
JAC	7 (5.6%)
Metavision	6 (4.8 %)
Cerner Millennium	3 (2.4 %)
EPRO	3 (2.4 %)
iCM (iSoft)	3 (2.4 %)
Proton	3 (2.4 %)
	Total: 64 (51.2%)

Table 2 - 6: The most commonly used electronic prescribing systemsamong respondent hospitals

2.5.4.3 Systems specifications:

System interface with other hospitals systems:

Figure 2 - 4 shows the extent to which systems were linked with the pharmacy dispensing software and other electronic systems. On the whole, systems used for discharge were less likely to be linked than those used for inpatient prescribing. Linkage with pharmacy systems was less common than linkage to other electronic systems. About 22% (n=7) of inpatient USHPs were linked with pharmacy dispensary while 13% (n=9) of discharge systems were linked. Nearly 70% of inpatients USHPs (n=22) were linked to another hospital system such as the patient administration system or clinical test results and about 30% of these USHPs were reported to interface with technology, such as smart pumps or bar coding. Fewer discharge USHPs were linked to other systems (39; 55%) or interfaced with technology (6; 8%).

Figure 2 - 4: Linkage of unique system-hospital pairs (USHPs) used for inpatient (n = 32) and discharge (n = 71) prescribing with pharmacy dispensing systems and other electronic systems.



'Unknown' comprises responses for 'not sure', and missing data
Decision support functionalities

There was wide variation in the decision support functionalities in systems used. Drug name selection from a menu was common (82% of all 125 USHPs, n= 102). Most of these systems (70%, n=71) also allowed free text prescribing. In ten and six cases respectively, respondents were not sure or selected "not applicable".

On the whole inpatient systems were more sophisticated than discharge systems. The use of decision support functionalities was more common in inpatient USHPs than discharge USHPs with the exception of 'free text prescribing' and 'providing a drug discharge summary'.

Figure 2 - 5 demonstrates decision support functionalities reported for all USHPs used for inpatients and discharge.

Comprehensiveness with respect to drugs prescribed:

Excluding systems used solely for chemotherapy, of the remaining 32 inpatient USHPs, 20 (63%, with 2 further respondents unsure) allowed users to prescribe CIVIs, 17 (53%; 5 unsure) supported prescribing of tapering doses and 22 (69%; 4 unsure) supported warfarin prescribing. Sliding scale insulin seemed to be the most challenging to prescribe electronically (11; 34%, plus five unsure and two selecting 'not applicable').

Supplementary paper-based prescribing was also reported for drugs such as heparin, gentamicin, vancomycin, controlled drugs and medication administered via syringe driver. Of the 13 hospitals using inpatient EP in all adult medical and surgical wards, all but one (8%) reported the need for supplementary paper prescription charts.



'Unknown' comprises responses for 'not sure', and missing data



2.5.5 Future plans for EP implementation:

Future plans for EP implementation reported by the 101 respondent hospitals were captured in this present survey (Figure 2 - 6). The vast majority of the sites (66.3%, n= 67) had firm plans to introduce EP system. Of these, 46 hospitals already had EP in place (17 had one EP systems and 29 had more than one). Nearly half of the sites who had plans to introduce EP (45%, n=30) had a timeline to between one - two years. A third were implementing the system in less than a year (30%, n=22) while the remaining 17 hospitals had a timeline of more than two years.

Only nine hospitals from all 101 respondents (8.9%) had no plans to introduce new systems. Of these, only one hospital had no EP system in place. Three sites did not disclose any information about their future plans.

Nearly 22% (n=22) of the respondents were not sure. However, about half of them (n=9) commented that their sites were looking into developing business cases. Some of the respondents mentioned the obstacles they face such as, financial constraints, technical issues (for instance, old buildings with no Wi-Fi), and changes in plans due mergers with other trusts. Table 2 - 7 shows examples of respondents' comments about barriers to their hospitals' future plans.

Figure 2 - 6: Future plans for EP implementation in 101 respondent hospitals n=67



EP: electronic prescribing

Table 2 - 7: Comments of respondents about hospital future plans to introduce electronic prescribing systems.

System choice

- We have looked at other systems recently which do not meet our requirements and require computer literacy to operate. So we decided to stick with our stand alone system
- Reasons for >2 yrs are financial + lack of a suitable system which can do
 everything we would like it to. We have a number of speciality specific
 systems in place which will be difficult to replace with a generic
 prescribing system

Technical issues

- The trust need to replace Patient Administration System. Preferred system identified but will not be installed until April 2012. This needs to be embedded before Trust will make decisions on which other system to select
- We are not Wifi as old building. Until his is sorted EP is implemented
- Possibly- depends when JAC delivers Its solution suitable software for Paeds
- The trust has employed IT consultants + a 'spec' is in the process of being developed. I am concerned following the GMC study on prescribing errors that an all England drug chart was a suggestion + now many different IT systems being used. This will be difficult for locum staff + Drs on rotations to different trusts.

Financial constrains

- Plans to roll out Ascribe live to all inpatient prescribing but currently no identified resources to do this.
- Reasons for >2 yrs are financial + lack of a suitable system which can do everything we would like it to. We have a number of speciality specific systems in place which will be difficult to replace with a generic prescribing system
- Sadly trust does not see the need for financial investment in this current NHS climate
- The trust executives are supportive of electronic prescribing but the current financial climate restricts us from such a heavy investment
- Dependent on finance
- Depending on funding availability

Administrative issues

- We were due to progress with JAC edischarge or eRx modules in forthcoming 12 months. However, due to move with [site 1] in 2015, A decision for an 'ehospital' across Both sites may mean no investment in the extension of JAC here until 2012- 2013
- Currently working with iSoft on the EDN system with [site 1], [site 2], [site 3]
- Trust is currently undergoing an acquisition process
- Waiting on Lorenzo as potential East of England solution

All comments are verbatim. Only identifiable information removed, e.g. Hospital name replaced by [site, number].

2.6 Discussion:

2.6.1 Main findings:

This survey established that EP is more widespread than previously reported in secondary care in England. However, there were variations in the extent of EP use within hospitals. Many of the systems were limited to specific wards or clinical areas. Moreover, only a few hospitals had hospital-wide systems that provided complete support for prescribing. Only one hospital used a system for inpatient, discharge and outpatient prescribing in all clinical areas. This particular system was developed in-house and has been in use for some time.

A more common model is the use of specialised EP systems for chemotherapy prescribing, and/or in specific clinical areas, and/or for discharge prescribing alone. This may reflect the drive to improve cancer care provision in the UK through local cancer networks as discussed in chapter one. These cancer systems have been designed to manage the whole patient pathway from oncology referral, including diagnosis, scheduling, laboratory tests, pathology tests, protocol based chemotherapy prescribing and administration as well as patient monitoring. Therefore, chemotherapy systems are potentially well ahead other form of EP used nationally.

Perhaps unsurprisingly, the use of EP for discharge prescribing is relatively common and where it is used, it is generally hospital-wide. One possible factor could be that the process of discharge prescribing is much simpler than inpatient prescribing. Since effective communication between primary and secondary care is essential for providing seamless care, the use of electronic systems to communicate medication changes to general practitioners is common practice in the UK. Half of the systems reported to be in use target this area. However, these systems were reported not to have very sophisticated decision support which is predictable. Many of these systems were based on standalone software working in isolation. Some hospitals developed their systems in-house and others used commercially available systems.

Overall the same systems seem to be utilised differently across various sites. However, differences were not only limited to systems specifications and/or prescribing comprehensiveness. This survey showed that same systems were also used in different stages of the patient clinical pathways in different hospitals. Such wide diversity in EP systems may potentially introduce risk. In a study conducted by Metzger et al, (2010), a national US sample of 62 hospitals voluntarily underwent an assessment to establish how well safety decision support worked when applied to medication orders in CPOE systems. The study revealed wide variation in the ability of implemented CPOE decision support, including among hospitals using the same systems, to detect medication orders judged likely to cause serious harm to patients (detection rate ranging between 10 - 82 % for individual hospitals). The findings of the study presented in chapter two and the literature demonstrates that arguably hospital EP systems are not used to their full capacity (Metzger et al, 2010; Ahmed et al, 2013).

A particular phenomenon of having multiple systems co-existing within the same hospital emerged from the results of this survey. A total of 39 hospitals

reported having more than one system (range 2-6). These sites are all currently looking into procuring a hospital-wide system. However, some of them acknowledged the challenge they face to find one system that can replace the multiple highly specialised systems. The majority of all sites are planning to introduce a new EP system- either introduce their first EP system, replace an old system or add on a new system to what they originally have. Many of the remaining sites are currently developing business cases for deployment but have no solid plans yet. A number of respondents commented that the current financial climate badly influenced their trust's future plans for obtaining EP systems.

2.6.2 Comparison with previous research:

The findings of this census suggest that EP is more widespread than previously reported in the UK (Summers, 2000; Cresswell et al, 2013). International comparisons are difficult as there are few similar studies. A survey conducted in the US in 2008 presented similar findings to this census (Jha et. al, 2009). Authors reported that hospital-wide computerised prescriber order entry was used in 17% of US hospitals with a further 11% of hospitals using it on at least one unit. However a different survey tool was used and it is not clear to what extent the findings are directly comparable.

A more recent US study reports 34% of hospitals as having computerised prescriber order entry for medication in 2011 (Pedersen et. al, 2012). This is comparable to the 31% figure of inpatient EP that was reported in the present study. However, it is unclear if the US figure refers only to hospitalwide implementation or includes use of EP in some clinical areas. Another study (Pedersen et. al, 2011) explored inpatient systems interface with the hospital pharmacy dispensing systems and reported similar findings to the present survey (22% UK; 22% US).

2.6.3 Implications for practice:

Overall, the findings of this work revealed a wide range of EP systems used across England. Many hospitals were found to be running several systems concurrently. The same systems were used differently in different trusts which further complicates the picture. It was found that hospital-wide inpatient EP was uncommon. However the use of EP systems for discharge prescriptions was prevalent. This could be attributed to the fact that the discharge prescribing process is less complex than the inpatients prescribing process. However, discharge systems generally had basic decision support. Many hospitals used EP systems for chemotherapy prescribing which is likely to have been driven by regional funding supporting cancer care provision in England.

The wide variation in systems and how they are used is likely to create challenges for healthcare professionals who may have to use multiple systems within a given hospital. They will also need to be trained to use different systems if they move between trusts. Although the patient safety consequences of this diversity are not yet known, there are potential risks associated with different systems having different decision support features, for example.

Recently, concerns have been raised about variation in inpatient paper drug charts resulting in calls for a national drug chart for England (Barber et. al, 2013). The much wider diversity in electronic prescribing reported in this survey has not been highlighted previously. Moreover, the lack of ability of EP systems to support prescribing of high risk drugs such as sliding scale insulin and warfarin and the use of concomitant paper systems is a major concern. Patients' medication records may be split between different electronic systems and also across electronic plus paper systems. There are potential risks of overlooking medication prescribed due to this split.

It is important to recognise that most of the literature demonstrating the benefits of inpatient EP has studied single hospital-wide systems, mostly in the USA. A recent report for the Minister of Health in England suggests implementation of EP should be a priority for hospitals' IT development (PriceWaterhouseCooper, 2013). The findings of the present survey suggests that in the near to mid-term future, prescribing in English hospitals will be often be delivered by a melange of multiple electronic and paper systems. This presents substantial challenges to the design of system interfaces, training of the mobile international workforce, and the design of safe systems of working, if EP is to deliver its expected benefits.

2.6.4 Strength and limitations of this survey:

A major strength of this survey is that a census approach was applied. All 165 acute NHS trusts in England were invited to participate, to document a picture of current practice that was as complete as possible. Although slightly lower than the generally acceptable response rate (Sitzia & Wood, 1998), a rate of 61% is similar or higher than similar surveys in the USA and UK (Crowe, 2010; Pedersen et. al, 2012; Pedersen et. al, 2011; Jha et. al, 2009) (Response rates of 28%, 40%, 51%, 63% respectively).

In contrast to previous work in this field (Summers, 2000; Cresswell et al, 2013), the uptake and functionalities of all EP systems in respondent hospitals were captured. This exposed for the first time the extent of multiple EP systems within a single hospital. Moreover the findings shed light on the stages of the patient pathway in which EP system were used and their extent of deployment. In addition, the comprehensiveness with respect to drugs prescribed as well as future plans of EP deployment in respondent hospitals were documented.

On the other hand, this survey has a number of limitations. First, the survey was conducted in English hospitals therefore findings can't necessarily be generalised to the rest of the UK. Second, the questionnaire was addressed to CPs as they were likely to have a broad overview of the systems in use together with an understanding of key clinical features. However, other potential respondents such as trust's IT teams may have responded differently. Third, the reliability and validity of the questionnaire was not formally assessed. However questions were factual in nature and our one-to-one piloting suggested the questionnaire had high face and content validity. Fourth, there were no specific questions about outpatient or day case EP systems. Therefore prevalence of EP in these areas may be an underestimate. Finally, we captured data on only the main acute hospital within multi-site trusts, which could have underestimated the number of systems in such trusts.

2.6.5 Recommended future research:

In the light of the findings of this survey, several future research recommendations could be made. First, assessment of the implications of having multiple EP systems within the same hospital is required. Some work was therefore done to explore reasons behind having multiple EP systems, its pros and cons, and the implications of multiple EP systems use on patient safety and is presented in chapter three of the present thesis. Second, exploring the implications of running parallel electronic and paper systems on patient' safety is recommended. Finally, system diversity is an area that should be explored as it is not clear how to best manage this diversity and drive technology use in secondary care forward. It also is important to establish if system diversity is a problem in other countries. Therefore, future research should focus on these issues.

2.7 Conclusions:

This survey of the EP use in English acute and foundation NHS trusts has allowed for an insight into current levels of EP use and likely targets of expansion. EP is prevalent in secondary care in England although often in limited clinical areas and for limited types of prescribing. Despite the wide uptake of EP systems, only a few hospitals had hospital wide systems that provide complete support for all forms of prescribing. EP for discharge and chemotherapy was more common. The diversity of systems in use will create challenges for interfacing between systems, staff training, and patient safety. The majority of hospitals were planning to introduce a new EP system in the near future. However, many reported difficulties under the current financial climate. The present survey revealed the phenomenon of multiple EP systems use in English NHS hospitals which was then further explored in another study which is described in the next chapter.

Chapter 3 Qualitative study exploring the phenomenon of multiple electronic prescribing systems within a single healthcare organisation:

3.1 Background:

As described in chapter two, a cross-sectional descriptive census of EP systems in acute and foundation NHS trusts in England was conducted in 2011 (Ahmed et al, 2013). The census showed that more than half of respondents who had EP in place had more than one EP system in use within the same hospital, ranging from two to six systems. Furthermore, the majority of hospitals with multiple systems also reported plans to introduce a new EP system in the future. The results of the survey therefore exposed the phenomenon of multiple EP systems operating within the same hospital, a finding which has not been explored before in the literature. Therefore a follow up qualitative study was conducted and is presented in this chapter.

3.2 Aim and objectives:

The present study aimed to further explore the phenomenon of multiple EP systems which emerged through the findings of the national survey of EP systems in English acute and foundation trusts (Ahmed et al, 2013). The objectives were to:

Describe the reasons for having more than one EP system within a single hospital.

- Explore the perceptions of end-users about the utility and the pros and cons of having multiple systems as well as the potential challenges faced by NHS staff using them and any potential impact on patient safety.
- Identify the motives behind any plans to replace the current systems and explore staff perceptions about the changes planned.

3.3 Methodology:

The following section provides grounding for the use of semi-structured interviews as well as the methodological considerations. The methodology section is then followed by a detailed description of specific methods applied by the researcher.

3.3.1 Conceptual framework:

The present study aimed to explore a phenomenon not previously reported in the literature. Therefore, it was decided to create an a priori framework to guide the present study with a view to modifying the framework as needed during the study. The framework themes were built on the questions that the researcher sought to answer. The framework was then tested and further developed during a pilot study and reviewed by PhD supervisors (BDF and YJ). Figure 3 - 1 demonstrates the initial conceptual framework used in the present study.

Figure 3 - 1: The conceptual framework developed to guide the interview and analysis process



* External to the trust or hospital

3.3.2 Considerations for data collection:

Interviews are one of the most common data collection methods in social research. There are essentially three types of research interviews: structured, semi-structured and unstructured (Bryman 2001; Ritchie and Lewis, 2003). In structured interviews a list of predetermined questions are asked, with little or no variation and with no scope for follow-up questions to responses that warrant further elaboration. Thus, they are relatively quick and easy to administer. However, they only allow for limited participant responses and are, therefore, of little use if 'depth' is required.

Conversely, unstructured interviews do not reflect any pre-defined ideas and have little or no organisation. Interviews usually start with an opening question and will then progress depending on the initial response. Therefore, generally they are useful when nothing is known about the subject area as they generate 'in depth' information. However, unstructured interviews are usually very time consuming and can be difficult to manage and analyse. Moreover, the lack of predetermined interview questions provides little guidance for participants on what to talk about.

Semi-structured interviews are the most frequently used interview type in healthcare research (Pope and Mays, 2006). As an in-between approach, semi-structured interviews consist of several key questions that help to define the areas to be explored, but also allows both the interviewer and interviewee to diverge. The flexibility of this approach allows for the discovery of issues that are important to participants but may not have previously been thought of by the interviewer yet also provides participants with some guidance on what to talk about. In the current study the researcher identified an a priori conceptual framework to guide the present study. Therefore the use of Semi-structured interviews was considered most appropriate.

3.3.3 Considerations for data analysis:

Qualitative data analysis methods considered for this study are described in table 3 -1 (Ritchie and Lewis, 2003; Silverman 2011; Strauss and Corbin, 1990). Qualitative method analysis can be broadly categorised into two different types. The first type is linked to a particular method or theoretical position. Methods under the first type include conversational analysis,

interpretative phenomenological analysis, grounded theory and discourse analysis (Braun and Clarke; 2006). They are all methods which can be said to sit within a broad theoretical framework. The second type includes approaches which are essentially independent of theory or epistemology. Therefore they can be applied across a range of theoretical positions. Examples of this type are thematic analysis and framework analysis. Framework analysis is a form of thematic analysis (Gale et. al, 2013). It was developed in the 1980s by Jane Ritchie and Liz Spencer from the Qualitative Research Unit at the National Centre for Social Research in the UK (Ritchie and Lewis, 2003). Framework analysis approach allows the researcher to systematically reduce the data, in order to analyse it by case (individual or site) and by code (theme). The present study sought to explore and understand the phenomenon of hospitals with multiple EP by interviewing a selection of healthcare professionals. An analysis approach which allowed the development of the conceptual framework as well as the comparison between study sites while retaining the context was sought. Therefore, framework analysis was considered most appropriate.

Table 3 - 1 Types of qualitative data analysis methods andconsiderations for use in the current study

Analysis type	Description	Appropriateness for the present study
Content	This method is used to analyse	Less appropriate for the
Analysis	review of documents,	current study. The present
	newspapers, reports or	study aimed to explore and
	narratives. It focuses on the	understand a new
	way themes are presented	phenomenon through
	therefore occurrences of words	semi-structured interviews.
	or themes are counted and	
Discourse	This method is used to	Less appropriate for the
Analysis	understand the way knowledge	current study. The present
	is produced through language.	study aimed to explore and
	Discourse analysis involves	understand a new
	analysing speech series,	phenomenon through
	propositions or sentences to	semi-structured interviews.
	produce theory	
Interpretative	This method is concerned with	Less appropriate for the
Phenomenolo	individuals' perceptions of	current study. The present
gical Analysis	events and or given	study aimed to explore and
	phenomena under certain	phonomonon but did not
	experiences contribute to their	seek to establish
	perceptions	interpretation of
		individuals' perceptions
Grounded	This method aims to generate,	Less appropriate for the
Theory	develop and verify theory from	current study. The present
	the data gathered. Grounded	study did not aim to
	theory is described as a	generate theory but to
	cyclical process involving the	explore and understand a
	continuous analysis of the raw	new phenomenon in order
	data in light of the themes	to develop
	generated by constant	recommendations for
Thomatic	This qualitative analytic	Could be appropriate
analysis	method is used for identifying	however it doesn't allow
anarysis	analysing and reporting	comparison between
	patterns 'themes' within data	cases like framework
		analysis
Framework	Framework analysis was	More appropriate, this
Analysis	developed for the purposes of	approach helped retaining
	applied policy research. It is a	the context of the study
	matrix based analysis which	and developing a priori
	allows comparison of themes	framework. It also allowed
	between and within cases.	comparison between and
		within study cases.

3.4 Methods:

Semi structured interviews were conducted using the framework developed for the purpose of this work. Study sites were selected from the respondents of the survey of electronic prescribing systems in acute and foundation NHS trusts presented in chapter two.

3.4.1 Participant selection

3.4.1.2 Study sites:

In order to be considered for inclusion, hospitals had to meet both of the following criteria:

- A. Reported the use of two or more EP systems in the same hospital in the previous survey.
- B. Have previously given consent to be contacted for a follow up study after the initial survey.

A total of 36 respondents met the above criteria. Hospitals were selected from these with the aim of achieving a maximum variation sample. A selection matrix was created to include a heterogeneous sample to maximise diversity of cases selected (Figure 3 - 2). The categories for the decision matrix took into account: number of EP systems in the hospital, likelihood of overlap (the extent to which the systems may be used for the same patients, and/or by the same individual healthcare professionals), and the main characteristics of the EP systems. System characteristics included how they were developed (commercial, home-grown or a hybrid), type of prescribing (inpatient and/or discharge), inclusion of specialist systems (chemotherapy, renal, critical care, etc.), and prescribing for specific age groups. A graphical representation of overlap in each possible study site is presented in appendix E. Assigning likelihood of systems overlap was based on the assumptions displayed in table 3 - 2. System overlap was considered in all possible systems pairings. Likelihood of interaction was considered high when the systems were expected to be used for the same patient population and/or used by the same healthcare professionals. For instance, a pairing of hospital wide inpatient system and a hospital wide discharge system fell under this category. Similarly, a pairing of hospital-wide inpatient system and an intensive care unit (ICU) system was considered of high likelihood of interaction as patients usually transition from ICU to general wards during their admission course. Likelihood of interaction was considered possible when the systems could be used for the same patient population and/or used by the same healthcare professionals. An example of a possible likelihood system pairing was a chemotherapy system and a hospital-wide inpatient system or an ICU system. Likelihood of interaction was considered low when the systems were unlikely to be used for the same patient population and/or used by the same healthcare professionals such as a pairing of an ICU system and a discharge system.

The preferred number of hospital sites for inclusion was four as this was the minimum number of sites required to include all variations of the decision matrix categories.

Table 3 - 2: List of assumptions to determine Potential likelihood of interactions/overlap between systems

Scenarios with high likelihood of interaction

- Hospital wide inpatient system and an ICU system
- Hospital wide inpatient system and a separate discharge system
- Hospital wide inpatient/discharge system and an ICU system
- Chemotherapy system and a second, separate, chemotherapy system
- Discharge system and a second, separate, discharge system*
- Hospital wide inpatient/discharge system and a separate discharge system*

Scenarios with possible likelihood of interaction depending how the

systems are used locally

- Hospital wide inpatient system and a chemotherapy system
- Hospital wide inpatient/discharge system and a chemotherapy system
- Hospital wide discharge system and a chemotherapy system
- Chemotherapy system and an ICU system
- Chemotherapy system and a renal system
- Renal system and an ICU system
- Renal system and an outpatient system
- Renal system and a discharge system

Scenarios of low likelihood of interaction

- Hospital wide discharge system and an ICU system
- Hospital wide discharge system and accident and emergency system

* (The likelihood interaction of two discharge systems was considered high unless the two systems were used for prescribing for two different patient populations. For example, interaction likelihood of two discharge systems used for adults & paediatrics respectively was considered to be low. Interaction likelihood of two discharge systems used for different clinical areas e.g. one for mental health and one for hospital was considered as possible).

ICU: intensive care unit.

3.4.1.2 Interviewees:

A snowball sampling technique was employed to recruit participants. The original survey respondents (pharmacists) were contacted via email in the first instance (Appendix F). These pharmacists were invited to participate in the study themselves or to nominate a colleague familiar with the systems concerned. During the first interview, participants were then asked to suggest other users who potentially use more than one EP system to be invited to participate in the study. The researcher aimed to recruit end-users of different professional backgrounds. When respondents reported multiple EP systems in other hospitals within the same trust, this was then also explored in the interview and data included in the analysis. The target number of interviewees was a minimum of 12 in total (a pharmacist, nurse and/or doctor and IT representatives from each participating hospital) with a view that the final number of interviewees will be determined once saturation has been achieved.



Figure 3 – 2: The screening and selection process of study participants

3.4.2 Pilot study

An interview guide was drafted on the basis of the conceptual framework (Appendix G). The interview guide questions were drafted by the researcher and later iterations reviewed by PhD supervisors (BDF, YJ). The questions were then piloted with one of the PhD supervisors (YJ) to establish appropriate technique, identify any ambiguous questions and test time feasibility. Pilot study was conducted between June and August 2014. Two pilot study locations were identified; these comprised one of the survey respondents (not included in this present study) and another NHS Trust with multiple systems who did not respond to the survey. Questions were piloted with pharmacists involved with EP from both sites to establish if questions gave an adequate range of responses, and if any issues needed to be incorporated in the interview guide. The questions were reworded if found to be ambiguous or if interviewees did not answer as expected during the pilot study. Data from the pilot study were excluded from the analysis.

3.4.3 Data collection

Data collection took place between September 2014 and January 2015. Interviews were conducted via telephone, or face to face in the case of London sites. A participant information sheet (Appendix H) explaining the aims and objectives of the research and a consent form (Appendix I) were emailed to all participants prior to each interview. Verbal consent was requested at the start of each interview. The interviewer did not constrain the interviews, ensuring that issues raised by the participant were also taken into account. The interviews lasted for a maximum of 45 minutes depending on the participants' availability and the degree of information required.

Page 97 of 305

3.4.4 Data analysis

Interviews were audio recorded and later transcribed by a professional agency. The researcher checked all transcripts of audios for accuracy. NVIVO 10 (QRS international[®]) was used to organise and manage data. The stages of the framework analysis approach were applied to manage coding and analyse the interviews. First, the researcher familiarised herself with the transcripts through reading and re-reading. Transcripts were coded using NVIVO line by line to identify predefined and emerging themes and subthemes from the raw data. A detailed coding tree is presented in appendix J. The interview framework was used as a guiding tool to analyse the information gathered from interviews and any other themes that emerged from the data were also taken into account. Emerging codes and themes were then refined by reading and re-reading the transcripts. Coding tree and all stages of refinement of the conceptual framework were reviewed by the PhD supervisors (BDF, YJ). Data were charted in framework matrices using NVIVO which were then used for analysis and interpretation. A sample of a framework matrix is displayed in appendix K.

3.4.5 Ethics approval:

NHS ethics approval was not required under the Health Research Authority regulations as the study involved the use of non-sensitive, anonymised interview procedures where the participants were not defined as "vulnerable". The study was approved by the UCL research ethics committee and registered with the UCL joint research office.

3.5 Results:

3.5.1 Study participants:

This section describes the study sites, the characteristics of the systems used and the interviewees who took part in interviews. Table 3 - 3 provides an overview of the study participants.

3.5.1.1 The organisations:

Of the four initial hospitals invited, only two accepted to take part in the study. Alternative hospitals were then approached for recruitment. After two further hospitals declined, the second choice of alternative hospitals selected agreed to take part in the study giving a total of four participating hospitals (Figure 3 - 2).

3.5.1.2 Interviewees:

As described above, the researcher aimed to interview a selection of professionals from every hospital recruited. The first interview in each hospital was conducted with the contact person (pharmacist) who completed the national survey described in chapter two. However there were challenges faced when attempting to recruit further interviewees from disciplines other than pharmacy. First, interviewees from two hospitals (A, D) felt that due to the nature of the EP systems they used, only clinical staff spread across different specialities, for example pharmacists, were exposed to the various systems. Therefore, the researcher sought to interview further pharmacists in these two hospitals to establish if this impression was accurate. Second, there were challenges in recruiting IT representatives from all four hospitals. Despite electronic and telephone follow up reminders no IT staff accepted to take part in the study. Therefore, as no IT staff agreed to take part, the researcher attempted to recruit clinical staff who either worked closely with IT or were involved in EP project management or implementation teams in the hospital. A total of ten participants agreed to take part in this research (Table 3 - 3). Three pharmacists were interviewed in hospital A. Two pharmacists, two doctors and a nurse were interviewed in hospital B. A pharmacist was interviewed from each of hospitals C and D.

3.5.3.3 Current systems within the selected organisations:

The researcher first sought to establish any changes which may have occurred to the EP systems since details were reported at the time of the survey. Overall, respondents from two hospitals reported no changes. One hospital undertook a business case to implement a trust wide ePMA and the pilot was scheduled to commence in late 2015. The fourth hospital had opted to stop using the EP aspect of one of the systems they had in place and was in the process of rolling out a hospital wide ePMA system at the time of conducting the present study. Table 3 - 3 displays the main characteristics of EP systems used in the study sites.

sites		Site A	Site B	Site C	Site D ^{***} Two acute hospitals	
		One acute hospital	One acute hospital	One acute hospital		
Number of systems		6*	3**	2	3	
Likelihood of		Mixed	Mixed	Possible overlap	Mixed	
systems		6 combinations	2 combinations high		2 combinations	
overlap		possible	1 combination low		possible overlap	
		2 combinations low			1 combination low	
Systems	How systems	All commercial	Two commercial,	One in-house, one	All commercial	
characteristics	were developed		one in-house	commercial		
	Type of	Two inpatient, three	One inpatient, one	One inpatient, & one	One inpatient, one	
	prescribing	discharge, & one	discharge, & one	mixed inpatient/	discharge, & one	
		mixed inpatient/	mixed inpatient/	discharge (ePMA)	mixed inpatient/	
		discharge	discharge (ePMA)		discharge	
	Use of specialist	ICU, Renal, Cancer	ICU		Cancer, ICU	
	systems					
	prescribing for		Paediatrics			
	paediatrics					
Interviewees		EP pharmacist	EP pharmacist	EP pharmacist	Chief pharmacist	
		2 senior pharmacists	Senior pharmacist			
			2 senior doctors			
			1senior nurse			
			(super-user)			

Table 3 - 3: Overview of the stud	y sites, system characteristics	and the interviewees
-----------------------------------	---------------------------------	----------------------

ICU: intensive care unit, ePMA: electronic prescribing and medicines administration.

* Hospital had 6 systems in 2011; one of the systems was no longer used for prescribing. A new ePMA system was piloted during the present study. ** Two systems used simultaneously in PICU, fluids prescribing on ICU systems while medicines prescribed on ePMA *** Trust had two different cancer systems, one in each acute site (each was linked to a different cancer network).

3.5.2 Findings:

Figure 3 - 3 demonstrates the expanded conceptual framework developed during the study which guided the analysis and interpretations of the findings. The results are presented in the same hierarchical sequence as the expanded conceptual framework in the following sections.



Figure 3 – 3: The expanded conceptual framework following analysis

Blue boxes represent the extended conceptual framework of the study. White boxes represent new themes emerged from the study. Red arrows indicate relationships.

3.5.2.1 Reasons for having multiple electronic prescribing systems:

a. Factors influencing adoption:

Having multiple EP systems in NHS hospitals was not planned. Many interviewees indicated that their intention was always to have one system. Adopting EP systems in hospitals was complicated by the sheer number of factors influencing the adoption process. The factors highlighted during interviews comprised drivers of system adoption, funding mechanisms, system governance and stakeholders involved. Mapping out these factors revealed that hospitals had several models of adopting EP systems (described in the next section). These models ran concurrently within the same hospital or trust which led to adopting multiple systems. Furthermore, some hospitals reported deficiencies in their IT strategic planning which created another layer of complexity.

b. System governance and strategic IT planning:

IT department involvement ranged from full control to just providing technical support depending on the system itself (Figure 3 - 4). Moreover, system governance and IT strategic planning varied between hospitals. Some felt there was a strong IT strategy while others thought that they lacked strategic IT planning.

Hospitals which reported a lack of IT strategic planning also reported having legacy systems. Legacy systems refer to outdated computer systems, or applications. In these hospitals, the IT department was reported to work in isolation. Interviewees felt that IT departments did not take the lead and were generally seen as technical support. A best of breed approach consequently

changed over time to organic growth of systems in the hospital.

'I think if you were to ask we would say that we were going for a best of breed approach where we pick the best piece of software but the reality is that it's evolved as time has gone by so we've sat there and we've thought we need a renal information system and we've bought one and then we've thought we need a discharge letter and we've bought one. So it's been the way that nobody's ever really had a strategic plan about how we develop things I think, it's just happened and then it's been a question of trying to get things to talk to each other at the end'

Interview 4, pharmacist, hospital A

Conversely, some hospitals had a strong, clearly defined IT strategy as well as integrated clinical and IT services. Interviewees reported project teams including clinical and IT staff working together. Hospitals which reported a strong IT strategy also reported fewer EP systems used. Furthermore, interviewees described initiatives developed to overcome some of the negative aspects of having multiple systems. The following quote is an example of a trust where clinical and IT staff work together. The interviewee was a pharmacist who led a team of both pharmacists and IT staff. The interviewee reported three systems all of which were strategically planned for and are likely to be in use for the near future.

'I am employed by pharmacy but I work across pharmacy and IT, because electronic prescribing project is a joint project between both. So, a number of my team are actually employed by IT'

Interview 1, pharmacist, hospital B

3.5.2.2 Models of EP adoption:

Three models of EP system adoption were identified. The first was trust-led adoption. Systems falling under this category were often used on a large scale within a hospital or trust and were driven by local necessities and/or national drivers. An example of this type was adoption of a hospital wide discharge system or an ePMA system. Governance of these systems usually sat within IT departments who were responsible for training end-users as well as systems maintenance with clinical input from end-users.

'if you are looking at the EPR/ePMA [electronic patient record/electronic prescribing and medicines administration] system which is a trust-wide system for prescribing all the drugs and electronic notes, IT will have a big major heavy say because at [hospital B] we have been electronic for quite a few years so the data downloaded on our current system is huge'

Interview 10, Nurse, hospital B

The second adoption model was clinician-led. These systems were

introduced by a specific clinical speciality and were limited to a clinical area

and/or used for a specific group of patients. An example of this would be ICU

systems. These systems were designed to support a complete clinical

pathway for patients and EP was only one aspect of such systems.

Interviewees suggested that these systems were often introduced for

benefits other than EP. Some interviewees also commented that some of the

systems were funded by the clinical speciality rather than centrally.

".....unfortunately the systems that we have in use, so [system 1] for cardiology, [system 2] for orthopaedics, [system3] for renal, they all bring benefits in addition to the prescribing abilities, so their systems are bespoke and built for that speciality. So for example the orthopaedic one will collect data for the bone registry and populate the letters, you can do bits in theatres and it will populate the letters for the stuff that's relevant to that speciality rather than being a 'does all' but does a lot very well as that speciality would like it done, I guess. So, the systems have e-prescribing as a part of the package but that's not the only thing that they do, so like an add-on I guess'

Interview 2, pharmacist, hospital A

Clinician-led systems often fell under clinicians' governance with some

support and input from IT. Super users (clinical staff experts in the system)

usually managed the systems, and trained fellow end-users.

'Myself and a couple of other colleagues manage the front end and the governance of the data that goes in there and what comes out in terms of teaching, training, ongoing support and maintenance of the system'

Interview 10, Nurse, hospital B

The third model of EP adoption was strategic clinical network-led EP

adoption. All systems which fell under this category were cancer systems.

These systems were similar in function to clinician-led systems described

above. The only difference was that they were shared between partners

(hospitals). The choice of the system was dictated by the specific cancer

networks these hospitals were linked to.

'I am not sure about the exact details but there was a push from the cancer networks to have chemotherapy electronic prescribing so the system was a project done in conjunction with [hospital X] and centre partners'

Interview 6, pharmacist, hospital C

Figure 3 - 4: Models for EP systems adoption

Trust-led systems adoption	Clinician-led systems adoption	Strategic clinical network-led systems adoption
 Large scale use Driven by local necessities and/or national drive Governed by IT department Example: A hospital wide discharge system or ePMA system 	 Limited use (area or group of patients) Driven by speciality needs Supports a complete clinical pathway (not only prescribing) Governed by the speciality Example: ICU system 	 Limited use (area or group of patients) but shared between hospitals Driven by strategic clinical network Supports a complete clinical pathway (not only prescribing) Governed by speciality across hospitals Example: Cancer System

IT: Information Technology, ICU: intensive care unit,

3.5.2.3 Effects of having multiple EP systems:

a. Positive effects of having multiple EP systems:

One of the main advantages reported was providing better functionalities

such as in-built safety features. Using bespoke speciality systems provided

unique prescribing support in their respective clinical areas. Interviewees

also suggested that speciality systems brought extra benefits other than

prescribing. An example of that would be fluid monitoring and balance chart

support in ICU system or protocols support in oncology systems.

Interviewees also highlighted the fact that the functionalities of bespoke

systems may be challenging to replicate on a general prescribing system.

'.....having bespoke systems, so if we think about the chemotherapy systems it does do a lot more and it is very set up to manage chemotherapy protocols which would be very difficult to do within [system 1; electronic prescribing and medicines administration system], so it really has been built to deal with that kind of prescribing. It also has a lot of other functionality around scheduling and making appointments so that the day unit can keep
their diaries. Then again, that would be quite hard for us to build into [system 1] in a way that works as well as it does for [system 2; ICU system] so bespoke systems will always do, will always work really well for that bespoke area and I think that is probably the key benefit'

Interview 1, pharmacist, hospital B

The multiple EP system approach enabled end-users to meet their clinical

speciality group needs, an advantage often unattainable when adopting

integrated systems as compromises are expected be made.

'The problem when you take an enterprise system approach is that everyone feels that they're making a compromise somewhere. So to just summarise, everyone feels that if you take a best of breed approach, everyone's got their own specific medical software; everyone feels that they've got something which suits their needs'

Interview 4, pharmacist, hospital A

Furthermore, adopting multiple systems allowed for an opportunity to align

forces with other hospitals to manage complex clinical cases such as sharing

cancer systems with other hospitals. Such collaboration allowed spreading

the load of patient care and systems management between linked hospitals

as well as sharing expertise and knowledge. However, collaboration was

reported to be effective in niche clinical areas, as sharing bigger systems

with partners was thought to be problematic.

'On the chemotherapy system, you are using a single system with the coproviders of that clinical service and that means that you're all working to the same protocol but you're also spreading the load in terms of adding protocols, checking protocols. So I think that it works to our advantage. We know that we're doing the same as [partner A], we're doing the same as [partner B] rather than having to continually develop the system yourself and I think that means if you're going to work with other people'

Interview 9, pharmacist, hospital D

b. Negative effects of having multiple EP systems:

Generally, many perceived disadvantages to having multiple systems emerged from the present study. However, when systems were used within discrete clinical areas disadvantages were generally limited to individuals exposed to more than one system. A typical example was healthcare providers spread across different disciplines, for instance pharmacists, who came across several specialist systems in their day to day practice. Conversely, negative effects of having multiple EP systems were more prominent if one of the systems adopted was hospital-wide as implications were on a bigger scale. Themes emerged relating to disadvantages of having multiple systems are outlined below.

1) Systems access:

Password burden was one of the prominent issues raised during interviews. Interviewees reported the difficulties they faced to remember multiple EP system passwords. In addition to the multiple EP systems used, clinical staff had to deal with passwords of other systems and/or medical devices as well as various email systems. Potentially undesirable behaviours such as using similar or sequencing passwords as well as noting them on smart phones or diaries were often used to overcome access related challenges.

'The passwords I have at the hospital, I have my NHS password, my hospital password, my [system 1] password, my [system 2] password, we were counting, might get a university password, I have about 7 passwords in the hospital. I make notes on my iPhone of my current passwords and I now I tend to cross-populate, I used to have separate ones for all of them and now I tend to ... the first one I change, I just change them all to the same password and then when it's triggered again do the same thing, which I'm sure is not what you're meant to do'

Interview 7, senior doctor, hospital B

Hospitals had to ensure that there was enough hardware to accommodate

multiple systems used. Hardware requirements had to be assessed carefully

to meet demands of accessing multiple EP systems on wards. Similarly,

devices had to be compatible with all systems. Procedures to allocate and

renew passwords had to be created in order to guarantee all staff were able

to access the systems when required.

'The second thing is around access and training, so there is more and more training that people need to do and as more systems come in, it is trying to fit all of that in and then making sure that the right people have got the passwords at the right time to be able to get into the system. You've got to make sure that you have got enough equipment available for everybody and that all the programs work on the same equipment, so that you are able to do everything from the one terminal if you need to. So, I think those are probably the big difficulties'

Interview 1, pharmacist, hospital B

The following extract illustrates the issues around access and competencies

in systems used:

'One that causes the problems, particularly weekends and bank holidays is our ITU [Intensive therapy unit] system because only a handful of people really know how to use it properly. Most people can access it although, most people don't feel confident with looking at it and knowing how to work out what the patient's... it sound like it's something straight forward, doesn't it, to work out what the patient is actually taking or being given but it can be quite difficult, a lot of us don't feel that confident with looking into it and knowing for sure what the patient is actually getting and what they are actually prescribed so I would say we are more likely to miss things and make errors because we are not all as familiar with the electronic systems as we would like to be or should be'

Interview 2, pharmacist, hospital A

Since some staff used some systems sporadically, they sometimes lost

access to the systems, because passwords expire or were forgotten, but

more critically they felt less competent using the systems. Such issues were

particularly problematic during out of hours and weekend coverage. Similarly,

senior clinicians were less exposed to some of the systems therefore they

were more likely to delegate medicines orders to junior staff.

'We have become dictators. We give the order then it's not our problem anymore, its someone else's problem. Junior doctors will have to sort out the orders while earlier I could have done some prescribing myself'

Interview 8, senior doctor, hospital B

Locum staff were equally affected by access and competence issues.

Interviewees mentioned practices like sharing passwords with locum staff

and shifting IT related tasks to trust staff if locums were incapable to handle

multiple systems.

'It's apparent now if we have locums that really if they don't know the hospital and the systems they are essentially fairly useless because somebody else has to look after all the IT input. IT is actually quite an important part of our working lives and the simpler and more error free it is, the better it is and I think two systems doesn't really promote that.'

Interview 7, senior doctor, hospital B

2) Training:

Many difficulties were reported related to training staff on multiple systems.

There were difficulties around induction as large numbers of staff were

involved. The scale of training required the release of a large number of staff

if training was carried out face to face. Although e-learning was sometimes

used, there was some resistance to e-learning and often staff had to learn on

the job. Moreover, customised training packages had to be developed

sometimes to accommodate users' needs and their access limits.

'I think where you have got staff who are going to work across systems, which is going to be rare but our pharmacy staff would be one example, then you've obviously got to train people on multiple systems. That can be complicated'

Interview 9, pharmacist, hospital D

Page 112 of 305

From a trainee point of view, interviewees reported that staff had to learn a lot in a relatively short time. Therefore, it was difficult for staff to retain much from training.

'Its two things you have to learn, I think the more information you have to learn the more chance there is of mistakes and given that we have a high turnover of junior staff I think it's a lot easier if they just have to learn one thing once'

Interview 7, senior doctor, hospital B

Challenges related to training on systems managed by other hospitals such

as cancer systems were outlined. Interviewees reported that often training on

cancer systems was organised by other hospitals therefore staff had to travel

to be trained on the system.

'A lot of that training actually takes place off site, so again that makes it very difficult because the system is managed by [partner X] so they actually have to travel over there to have their training and it is more time for people to have to learn and then it is a lot of information in a very short period of time for new staff, learning all the different systems, so it can be a bit confusing for them, I think.

Interview 1, pharmacist, hospital B

3) Effect on workflow:

People changed some of their workflows to accommodate multiple system use. However, it seems that workflow changes were more problematic at the start but then staff adapted to the new ways of working. The following quote illustrates an example of workflow changes due to multiple systems use. One of the hospital wards had two EP systems used for prescribing for the same patients. 'People have had to change their way of working. So you might do something in a particular order but actually now that we've got [multiple] systems in place you might have to do it in a different order or you might have to approach your tasks in a slightly different way. So, where possible we have tried to outline ways to do that but what you find is that users actually find their own way to do it.

Interview 1, pharmacist, hospital B

Although rare, workflow issues were more serious when the same patient

admission data were spread between two electronic systems. Staff had to

login to two different systems and locate the same patient records to

prescribe, which was not only cumbersome but risky.

'You would prescribe your anaesthesia in [anaesthesia system] and when you want to give a bolus of a drug post OP [post-operative] you have to go and login into ePMA [electronic prescribing and medicines administration]'

Interview 7, senior doctor, hospital B

4) Duplication of work:

Duplication of work and consequently increased work volume was one of the

negative aspects emerging from the interviews. Duplication occurred in small

tasks such as entry of the same data in different systems as well as major

tasks such as maintaining drug catalogues.

'The other obvious disadvantage with the bigger systems is that you're having to maintain multiple catalogues and that's going to be an issue between the ITU [Intensive therapy unit] system and the main electronic prescribing system when we have it, that you're going to be having to update and maintain the catalogue twice with your formulary decisions twice and the opposite to the advantages of sharing a system with other people is that the more its shared the less individual control you have. So the more separate systems you have you might be doing something in one system and you can't do it in the other one because it's not your decision to make'

Interview 9, pharmacist, hospital D

Duplication sometimes also involved nursing related processes such as

intravenous infusion line checks or documenting observations.

'We do have to replicate data for intravenous line infusion checks so we do that on our [ICU system] as well as the [electronic prescribing and medicines admiration] system. We thought it might be an unnecessarily large amount of work but, since we have implemented it, as we are doing it on an hourly basis on our system, when it comes to doing it say every four hours as part of the drugs check, it is actually done very quickly '

Interview 10, Nurse, hospital B

5) Challenges faced when attempting to interface systems:

All interviewees agreed that attempting to interface the systems was difficult.

One of the possible explanations was the complexities of some systems or

the differences of the intelligence behind each system. Therefore what in

principle comes across as a logical process was actually far more

complicated.

'The other disadvantage is that I think we all think that interfaces are easy; if you've got an electronic system surely you must be able to link it to another electronic system. It's not, in my experience, it's not that easy'

Interview 9, pharmacist, hospital D

6) Patient safety:

One of the main concerns about multiple systems use was the effect on

patient safety. As implied in earlier sections, many disadvantages of multiple

EP systems use affected patient safety to a certain extent. For instance

aspects related to training staff and system access.

'it is making sure people know that there is information in different places, making sure that they are trained, making sure nothing gets missed, making sure that prescribers are putting the drugs into the systems being used in that area, which I think can be difficult and then obviously if you have got a new system there are training issues and making sure that people are able to use the system effectively to deliver patient care, so I think there are definitely risks. It would be much less risky if you just had one system but we have to just find ways to mitigate those risks'

Interview 1, pharmacist, hospital B

Having patient data spread across multiple EP systems hindered healthcare professionals from obtaining a complete picture of the patient journey. For instance a doctor or a nurse handling an outlier patient might not be aware about important patient related clinical data because they have no access credentials to a specific system. Some interviewees reported Incidents where diagnosis of a newly admitted patient was delayed because of a 'black hole' in the patient prescription records.

'I think that's the point and I think we've had a couple of occasions where a patient has been admitted, they're generally unwell and it's taken a little while for everybody to piece together the puzzle to say actually this patient's getting this type of care and therefore there is a prescription and this is what they're being prescribed and its happening somewhere else in our organisation but we can't readily see that record'

Interview 9, pharmacist, hospital D

On the other hand, duplication of patient data in various systems was

identified as potential clinical risk. For instance, a slightly different story might

have been documented in each system, which is undesirable.

'I think also there is another issue actually around duplication of information, so do people need to record things across different systems or can they put it in one place and expect that it will be found, and actually we don't want people to have to duplicate stuff because we might get a slightly different story in each system. You want it recorded once and then for people to know where to find It'

Interview 1, pharmacist, hospital B

In some instances, systems were not completely paperless. Therefore,

healthcare professionals were faced by a mixture of paper charts and data

spread across EP systems. The next quote is an example of a unit where

doctors used two electronic systems and a paper drug chart simultaneously.

'Part of pain management is on paper. It's always at night when its HC [healthcare assistant] bank nurse and a locum doctor when this paper is missed'

Interview 8, senior doctor, hospital B

In-built safety features of systems introduced risks, especially when

healthcare professionals were accustomed to a certain feature not available

in other systems they had to use.

'You may get used to a system doing a certain thing when you move to the other system and it doesn't do it, that could create a risk because in your other system it's automatically checking. Perhaps some PAS [patient administration system] results you can have them there available and you're not going to have them in the other system'

Interview 9, pharmacist, hospital D

3.5.2.4 Workarounds used to tackle disadvantages of multiple systems:

Hospitals developed various workarounds to reduce disadvantages of multiple systems use, improve user experience and therefore improve patient safety. These were reported by hospitals that had innovative integrated clinical and IT services. For example, hospital C linked both EP systems with a PAS system. They created a one way allergy data feed from their main ePMA system to their chemotherapy system. However, they reported that setting up this interface was rather complex.

System dummy prescriptions and/or flags were another example of workarounds used. Dummy prescriptions are records alerting healthcare professionals of prescriptions they may not be able to see. Dummy prescriptions and flags alerted healthcare professional to other prescriptions existing on paper and/or other electronic systems. 'There is a manual alert on our main PAS [patient administration system]. For example if the patient is under our care and known of receiving chemotherapy, an alert is put into the main electronic prescribing system that will come up when activating the patient. I think it says this patient has meds chemotherapy or something similar but that's a manual update, which is done by some of the oncology nurses'

Interview 6, pharmacist, hospital c

All hospitals were exploring the introduction of a 'single sign on' to alleviate

password burden of their staff and improve their user experience.

'At the moment its passwords but we're going to a system called Single Sign On, so it's with a smart card but also you will have a piece of software that connects you and your smart card to all of your system access and all of your passwords. So you will only effectively need your smart card and one password to get into all systems'

Interview 9, pharmacist, hospital D

3.5.2.5 Future plans for EP systems and staff perceptions about changes:

Future IT plans reported by interviewees suggest that hospitals aimed to move away from paper based prescribing. As presented earlier, two hospitals (A, D) had no hospital-wide inpatient EP systems in place at the time of the survey. Of these, one hospital (A) was in the process of rolling out an ePMA system during the present study. The other hospital (D) planned to commence a pilot of a new system in 2015. Interviewees from both hospitals agreed that patient safety was the main driver for ePMA adoption. They also acknowledged that due to various reasons, their hospital IT strategy was to attempt interfacing multiple EP systems on PAS rather than purchasing a fully integrated system. One explanation was related to the trust's IT history, for example prior unsuccessful EPR adoption. Moreover, interviewees highlighted that their trusts did not want to waste money spent on EP systems they already had in place.

The remaining two hospitals (B, C) reported future plans to replace their main ePMA system. The two hospitals had various drivers for system change but both reported their systems were old and clunky. In addition, the system used in hospital C was not compatible with some of the newer hardware and technologies they were using and the system had little room to improve user interface experience while the system used in hospital B was not going to be developed further by the system vendor. The decision of which system to phase out was complex. It seems that some niche specialist systems such as oncology systems may remain in use alongside hospitals main ePMA systems with the hope of interfacing them at some point. Interviewees from hospital A expressed concerns about resistance they might face when trying to phase out legacy systems.

3.5.2.6 Challenges for systems' adoption:

It was suggested that financial constrain was one the main of the challenges encountered by NHS hospitals. Some interviewees reported that many business cases were rejected due to costs. However, the positive influence of the recent government fund on trusts plans of system adoption was emphasised. The following two extracts illustrate some of the issues raised by interviewees related to funding EP systems:

'I think we were lucky that we were already part way through the process when the Department of Health released the additional funding so we were in the first wave of hospitals funding and we were able to secure some of that funding to support the project'

Interview 9, pharmacist, hospital D

'Well I think government fund certainly made a massive difference to the [hospital wide ePMA] system because its 50% funded by the NHS Safer Hospital, Safer Ward Technology Fund and this wasn't a new idea to buy this software. Various business cases have been submitted over the last few years and they've always been rejected'

Interview 4, pharmacist, hospital A

Managing users' expectations about the systems was another emergent

theme from the interviews. As illustrated earlier, all study hospitals intended

to adopt a best of breed approach. However, achieving comprehensive

linkage between EP systems was unlikely as interviewees acknowledged the

difficulties of interfacing multiple systems. Interviewees highlighted NHS staff

frustrations due to lack of integration between systems particularly as they

apply their standard of IT use in day to day life.

'I think that it's the user's expectation that they expect the systems to talk to each other and they don't and I think that's hard to manage, people saying "well, why doesn't the blood result feed into this one?" and you say that there is no link, you actually do have to look in this other place for it, so there is definitely some difficulty around managing expectation'

Interview 1, pharmacist, hospital B

'Oh yes. I think it's really difficult with IT in the NHS because of what we know we can have just in our general day to day life and how we see systems working in everything that we do and we're so used to IT.... when you then try to apply that standard, that expectation to what we can achieve in NHS systems it's really frustrating that it's so difficult to do the same thing'

Interview 9, pharmacist, hospital D

Interviewees raised some issues around EP systems capabilities. It was

suggested that perhaps advances in technology were not keeping up with

the rapid changes of healthcare. Therefore, systems were incapable to

support the management of complicated patients.

"... system at the moment struggles to deal with patients who have got several booked admissions for different types of care and that may be because when the system was first developed patients perhaps were only expecting them to be lining up to come and have one type of treatment. Now patients have so much co-morbidity and are living so long that we can expect them to have lots of things happening all at the same time and our electronic prescribing system doesn't cope very well with that'

Interview 9, pharmacist, hospital D

Interviewees acknowledged the lack of sufficient expertise to manage EP

systems within the NHS. While IT departments provided technical support for

EP systems, clinical input was provided by end-users. The separation

between technical and clinical skills may have hindered appropriate system

management. Interviewees highlighted the need of people with both clinical

and IT knowledge.

'At the moment, the responsibility of the [hospital wide discharge system] kind of sits with IT. That can be problematic in terms of its good because it's an IT system and therefore the technical aspects of what need to be done are within their remit anyway, but when you're looking at it in terms of a clinical system that does cause a problem. We have a clinician who is nominated within the organisation as being the person who will take decisions around the [discharge] system, but again he'll be doing it from a very clinical perspective rather than an IT [.....] I feel that we will probably see a shift and maybe start to have some clinical IT posts more than pure IT posts that have got a responsibility in both areas'

Interview 9, pharmacist, hospital D

3.6 Discussion

3.6.1 Key findings:

The phenomenon of multiple EP systems use was not explored previously in the literature. However, multiple EP system use was reported to cause medication errors (Schiff et al, 2014). The present study revealed that adopting multiple EP systems in NHS hospitals was not strategically planned. EP systems' adoption was affected by several internal and external factors. Mapping these factors revealed three models of EP system adoption which co-existed in NHS hospitals: trust-led, clinician-led and strategic clinical network-led system adoption models. Therefore, system governance and IT involvement varied considerably between systems. There were EP systems governed completely by IT, others by clinicians and some even governed by other hospitals.

Having multiple EP systems was perceived to be advantageous, particularly in the context of systems used in niche clinical specialities. Bespoke systems supported not only prescribing but other clinical processes and therefore enabled clinical speciality groups to meet their specific needs. Nevertheless, there were many global disadvantages related to multiple EP systems use reported by the interviewees, all of which were perceived to impact on patient safety. However, the main negative aspect revealed was distortion of the documentation in patients' journey. In some occasions, healthcare professionals were missing key information and/or not were able to obtain a full view of their patients' journey. Moreover, healthcare providers sometimes dealt with hybrid electronic systems which varied in features and/or paper systems. All of the issues discussed above introduced clinical risk.

It seems when used within discrete areas, having multiple EP systems offered advantages while negative impact on staff was mainly on those staff spread across various disciplines. However, implications due lack of integration with other systems remain valid.

Various workarounds to mitigate some negative aspects of multiple systems use were identified. The use of dummy prescriptions to alert clinicians about prescriptions on paper chart and/or other systems was used. Furthermore, attempts to create feeds or linkage between systems were made. However, these were reported to be challenging. All study sites were exploring 'single sign on' system to reduce password burden.

It was suggested that due to various reasons, hospitals would retain the multiple systems approach for the near future. All hospitals had plans to introduce, or replace, a hospital wide ePMA system. The main driver for systems adoption was achieving paperless prescribing and improving patient safety. Two sites were successful in securing a government award to finance some of the capital costs of the systems. Interviewees highlighted that previous attempts to make a case for system purchase were rejected due to financial constraints.

Some of the challenges faced by hospitals with multiple systems were highlighted in the study. Some of which were external therefore hospitals had no control on such challenges. Examples of such challenges are the capabilities of the systems and the current financial climate. However, some

Page 123 of 305

of the challenges reported were internal. For instance, hospitals struggled to manage end-users expectations' of systems integration. Moreover, providing specific expertise to manage and maintain clinical systems such as EP systems was a challenge.

3.6.2 Implications for current practice:

The findings of the present study suggests the importance of integration between clinical and IT services on both management level and day to day practice. The study showed that hospitals with innovative integrated IT and clinical services reported less legacy systems. Moreover, these hospitals developed workarounds to reduce some negative impacts of multiple EP systems use. The findings also highlighted the need for staff with both clinical and IT expertise to maintain and manage clinical systems. Therefore, the recruitment of clinical staff with relevant IT expertise is advisable.

Hospitals hoped that legacy systems would be phased out in the future. However, the use of speciality bespoke systems in niche areas, such as cancer systems, was deemed to be irreplaceable. Therefore, efforts should be directed towards interfacing such systems or the development of suitable workarounds to ensure patient safety.

The study revealed practices used by end-users to reduce password burden. Sequencing passwords and/or noting them on smart phones or diaries is a potential security risk. Our findings suggest that the use of 'single sign on' system in hospitals with multiple EP, or similar clinical, systems should become common practice.

Page 124 of 305

3.6.3 Strengths and limitations of the study:

The present qualitative study was the first study exploring multiple EP systems use, a phenomenon rarely described in literature (Schiff et. al, 2014). The work revealed and described various models of EP systems adoption in UK NHS hospitals.

The study had several limitations. First, the study was purposively sampled to provide maximum variations sample. Although care was taken in the development of a selection strategy of study sites, it is possible the sample selected may not adequately reflect the study population. Second, despite efforts made to include healthcare professionals of various backgrounds. most of the interviewees were pharmacists. There were only two doctors, one nurse interviewed and no IT representative agreed to take part. Therefore, it is possible that the views and opinions voiced by interviewees may not adequately reflect those of other healthcare professionals. Third, similar to other qualitative methods, the structure of the interview guide used and the skills of the interviewer may also influence the nature of the responses (Pope et al, 2000). It is possible that interviewees were to a degree influenced by such factors. However, every effort was made to maintain a neutral position. Moreover, the interview guide did not constrain the interview. Issues raised by the interviewees were taken into account while analysing the findings. Finally, it was sometimes difficult to ascertain if drawbacks reported by interviewees were related to EP use in general or specific to multiple EP systems use. However, every effort was made by the researcher to follow up and probe if these effects were attributed to multiple EP systems.

3.6.4 Future research recommendations:

The study presented in this chapter explored hospitals with multiple EP systems, a phenomenon not described before in the literature. The findings of the presented work established various drawbacks to multiple systems use which may influence patient safety. Therefore, a future study to gain further understanding of these drawbacks and examine the potential clinical impact of multiple EP systems on patients' safety is recommended. An indepth case study based on observation of a selected hospital with multiple EP system is proposed. Through observation, the researcher would be able to documents and describe implications of multiple EP systems use on patient safety.

Workarounds developed by end-users to mitigate risks were reported. The present study was not set to explore workarounds and other initiatives. Therefore, other initiatives or workarounds used by hospitals not reported in this chapter may exist. The creation of a study to explore potential initiatives and workarounds used by hospitals to alleviate negative aspects of multiple EP systems use is recommended. Such knowledge will help inform policy makers and end-user decisions and improve patient safety.

3.7 Conclusion

The present study revealed that the complexity of EP systems' adoptions may have contributed to the phenomenon of multiple EP systems use in NHS hospitals. Three co-existing models of EP systems adoption in hospitals with multiple EP systems were identified. Although there were some perceived benefits of multiple EP system use particularly in niche clinical specialities, there were many global disadvantages described. Hospitals with innovative integrated clinical and IT services described various workarounds used to mitigate negative aspects of multiple systems use.

Study sites reported ongoing projects to implement a new or replace an old existing hospital-wide ePMA system. The main driver of the new system adoption was to achieve paperless prescribing and/or improve patient safety. The findings of this study suggest that in the near to mid-term future, multiple EP systems use is likely to remain in place in some NHS hospitals. Therefore, hospitals may attempt interfacing current EP multiple systems instead of procuring a complete integrated hospital system. The present study explored EP systems use in the context of NHS trusts embracing the best of breed approach. Further qualitative work in a UK NHS trust implementing a commercial ePMA integrated into EHR will be presented in the following two chapters (four and five).

Chapter 4 Implementation of an electronic prescribing and medicines administration system integrated into an electronic health record in an NHS trust: Stage one-participant observation

4.1 Background - chapters four and five:

Although HIT, including EP systems, are becoming central to healthcare, introducing them in healthcare organisations is challenging and carries the risk of failure. It became apparent that both human and organisational factors are critical for any HIT implementation (Lorenzi et al, 1997). Lorenzi and colleagues made suggestions on how to develop tactics and processes that help to implement change. Ineffective communication, underestimating the complexity of implementing a project, failure to clearly define and then maintain the project's scope and timelines, organisational and leadership issues as well as poor technology have been cited in the literature as reasons for failures in HIT implementation. Lorenzi & Riley (2003) highlighted that failure of HIT implementation can be outlined in four major categories: technical shortcomings, project management shortcomings, organisational issues, and the continuing information explosion.

Organisational memory loss, also known as organisational or corporate amnesia, has been cited as one of the major challenges for HIT deployment (Kransdorff, 1998; Bate et al, 2008). Knowledge of and lessons learnt from the process are forgotten, or organisations fail to accumulate them (due to documentation issues or workforce changes). This can prevent the potential improvement of future implementations and also hinder the sharing of the knowledge with others. Both future improvement work and organisational growth aspiration can then be affected which can be frustrating for staff and management.

All the above mentioned issues have been experienced in different ways by different originations/stakeholders and these issues might change overtime. Hence, appreciating the context in which HIT systems are being implemented is vital for success (Chiasson and Davidson, 2004; Kaplan, 2001, Greenhalgh et al, 2009).

There is little documented about contextual and organisational issues which may emerge when introducing a hospital-wide EHR system with integrated ePMA in a UK setting. The next two chapters describe two qualitative studies conducted in a UK NHS Trust implementing a hospital-wide EHR with integrated ePMA system (chapters four and five). The implementation project started in March 2011 and the ePMA system went life in March 2015. The first study (chapter four) involved participant observation of the earlier stages of the implementation project between May 2011 and June 2012. Chapter five presents a case study involving semi structured interviews carried out during the final stages of the implementation project as well as a document review of all minutes, agendas and documents accumulated throughout the whole project life cycle.

4.2 Introduction:

Adopting technology in a healthcare setting is challenging and not always successful (Connolly, 2005). Structured planning is vital to ensure successful implementation. There is no 'one size fits all' technology. Arguably, implemented systems will require extensive customisation to come up with a product that suits the hospital layout, facilities and mimic the current operational processes. Therefore, the final solution will often be unique to each healthcare setting. However, the journey from purchasing a system to its operational use can be very extensive. Enormous work is required before reaping the benefits of a stable system. Hence, active involvement of healthcare staff representing all disciplines in the hospital is essential to achieve success.

In the UK, CfH has invested into providing guidance to healthcare institutions embarking the challenge of adopting novel technology such as EP systems. Several supporting documents have been published in this area and are publically accessible (CfH, 2012). Moreover, guidelines for safe on-screen display of specific medication information were also compiled by the national patient safety agency (NPSA) to support safe EP (NPSA, 2010). More recently, a toolkit was developed to guide hospitals implementing EP systems (NIHR ePrescribing Research Programme, 2015).

As described in earlier chapters, to achieve the goal of paperless prescribing, a sizable proportion of NHS hospitals will face a choice of procuring a complete integrated ePMA or expanding on the multiple EP systems they already have in place. The previous chapter highlighted potential drawbacks of multiple EP systems use which is one of the arguments for adopting a single hospital-wide system. However, little is known about the issues which may emerge when introducing a hospital-wide system in a UK setting. The purpose of the present study was to understand the adoption of an 'off-theshelf' full EHR with integrated ePMA.

4.3 Aim and objectives:

The current exploratory study aimed to gain an insight into the adoption of an integrated ePMA system in the context of an NHS teaching trust. The objectives of the present study were:

- To describe the complexity of an integrated ePMA system adoption and its implementation process.
- To establish the following aspects of the project:
 - \checkmark The scope and timeline of implementation.
 - ✓ The project management structure and processes.
 - ✓ The relationship between the trust and the vendor.
 - ✓ Stakeholders involved in the implementation process
- To gain insights that can guide a further qualitative interview study with the main stakeholders involved in the ePMA implementation project in the trust (presented in chapter five).

4.4 Methodology:

A detailed description of the methodological considerations and the approach taken in the present study is presented in this section. The justifications for the use of participant observation as a method for data collection are presented followed by a discussion of the aspects related to the use of such approach. The specific methods used are detailed in a subsequent section.

4.4.1 Approach:

As previously stated, the purpose of this study was to gain an insight into an ePMA system implementation journey within the context of a UK NHS trust. A qualitative approach was considered most appropriate because the researcher sought to develop an understanding of the implementation journey as well as the interaction between the trust staff and the vendor. Qualitative research enables researchers to understand some aspect of social life and facilitate to answer the 'what', 'how' or 'why' questions about a phenomenon. The researcher wanted to answer the following questions: what was the project management structure? What were the processes involved? and how was the interaction between the trust and the vendor? Participant observation was used and is explained in the following sections.

4.4.2 Participant observation:

Participant observation has been a hallmark of both ethnography and case study research. Observation was defined by Marshall and Rossman (1995) as: 'The systematic description of events, behaviours, and artefacts in the social setting chosen for study'

Marshall and Rossman, 1995, P.97

Schensul et al. (1999) defined participant observation as:

'The process of learning through exposure to or involvement in the day-today or routine activities of participants in the research setting'

Schensul et al., 1999, P.91

As illustrated above, both definitions establish that participant observation

enables researchers to learn about the activities of the people under study in

the natural setting through observing and participating in those activities.

Thus the researcher will be able to describe existing situations using their

senses.

'A participant observer immerses him or herself in a setting for an extended period of time, observing behaviour of a group, listening to their conversations and asking questions'

Bryman, 2001, P.291

Observation provides researchers with ways to check for nonverbal expression of feelings, determine who interacts with whom, understand how people communicate with each other, and to check the time spent on various activities (Schmuck, 1997). It also provides a context for the development of sampling guidelines as well as interview guides and allows understanding of terms that participants may use in interviews (DeWalt & DeWalt, 2002). Moreover, researchers may be able to observe events that participants may be unwilling or unable to share and clarify any inaccurate description of events they convey (Marshall and Rossman, 1995). Schensul et al. (1999) highlighted the following reasons for using participant observation in research: 'to identify and guide relationships with informants; to help the researcher get the feel for how things are organized and prioritized, how people interrelate, and what are the cultural parameters; to show the researcher what the cultural members deem to be important in manners, leadership, politics, social interaction, and taboos; to help the researcher become known to the cultural members, thereby easing facilitation of the research process; and to provide the researcher with a source of questions to be addressed with participants'

Schensul et al., 1999, P.91

In the present exploratory study, the researcher wished to immerse herself in the setting to develop an understanding of the implementation project scope, structure and process. Therefore, participant observation was selected to achieve the objectives of the present study. Moreover, the researcher desired to interview key stakeholders in a further qualitative study presented in chapter five. Participant observation was considered favourable as it allows the researcher to understand the context of the field study and observe communications between various stakeholders in order to achieve the researchers' goals.

4.4.2.1 The stances of the observer:

Roles of the observer:

One of the standard classifications of observer's roles was set by Gold (1958). According to Gold (1958), a researcher would assume one of the following roles:

1. Complete participant: the research would be a fully functioning member as a participant (therefore assuming a covert role).

2. Participant as observer: the researcher would be a fully functioning member as a participant but members of the setting are aware of his/her identity as a researcher.

3. Observer as participant: less or little involvement as a participant

4. Complete observer: No participation or interaction with people.

Overt versus covert role:

A participant observer may assume a covert or an overt role. In a covert role, researchers do not disclose their role as researchers but behave as participants only. Although such strategy allows easy access to the research field, it raises ethical issues (Bryman 2001). For instance, a covert observer will be deceiving participants and they will be lacking informed consent. Also, there are increased chances of researcher bias as an observer adopts the lifestyle, behaviour and outlook of the participants which is known as 'going native'. An advantage of covert observations is reducing problems related to observer-effects and therefore it may be considered to be higher in validity than overt observations.

In contrast, researchers will disclose their role and intentions in the study field when assuming an overt role. Unlike covert observations, this approach doesn't raise ethical issues and observers are less likely to become over familiar with participants. However, participants may act in a way they believe is expected by the observer. The distinction between overt and covert role is not always straightforward. For instance, an observer might be assuming an overt role but he or she might come in contact with people unware of their status as a researcher (Bryman 2001).

In the present study, the researcher intended assuming an overt role due to the ethical implications of not disclosing her role. The researcher also intended assuming an observer as participant role. This role was selected as it allowed the researcher to maintain some connection to the setting and to participate in the group activities as desired yet focus on collecting data.

4.4.2.2 Field notes:

Registering experiences of the observer is the backbone of collecting and analysing field data (Bailey, 1996). It's fundamental to record observations field notes as soon as possible to ensure a comprehensive account of the researcher experience in the study setting (Bailey, 1996; Lofland et al, 2005). Lofland and colleagues (2005) identified three components of field notes. First, mental notes which are recollections of the researcher experiences in the field. Observers may be faced by a huge amount of detail in a new setting therefore they must train themselves to remember observations. The second component of field notes is jotted notes. Jotted notes consist of key words, phrases or short quotes registered by the researcher. Jotted notes are beneficial as it acts as a cue for mental memory. Mental and jotted notes form the basis of the detailed field notes which are the third component of field notes. The observer should aim to expand their jottings into complete field notes ideally on the same day of the observation. Bailey (1996) suggested that the stage of compiling detailed field notes is the start of the analysis process. In the present study, the researcher attempted to record

contemporaneous field notes following the approach described above (Lofland et al, 2005).

4.4.3 Data analysis:

Qualitative research analysis is an area of great debate. Many of the social science fort books seems to propose a generic approach to what is technically inductive analysis of qualitative data (Gibbs; 2007, Boeije; 2010, Bazeley; 2013). Alternatively, qualitative analysis may be carried out deductively, or using a combination of inductive and deductive approaches, if the research was influenced by a priori knowledge (Pope and Mays, 2006).

As described earlier in chapter three, thematic analysis is a qualitative analytic method used for identifying, analysing and reporting patterns and 'themes' within data. It is a widely used yet rarely acknowledged analytical approach (Braun and Clarke; 2006). Similar to grounded theory, analysis is driven by data in this type of analysis. However, in contrast to grounded theory, thematic analysis attempts to identify specific types of phenomena but not to identify their underlying causal structure (Boyatzis; 1998). Unlike other analytical methods, thematic analysis is not tied to any particular epistemology or discipline. The advantages of thematic analysis over grounded theory are that it is less complex and more flexible, and if done appropriately, may offer reliable results. Thematic analysis enables researchers to get close to their data and develop some deeper appreciation of the content. Also researchers interested in identifying broader patterns in their work in order to then conduct a more fine grained analysis often use thematic analysis as a first step. The present exploratory study aimed to set the scene and guide further qualitative research as described in earlier sections. The researcher aimed to identify key themes or patterns to guide the choice of a conceptual framework for the study presented in chapter five. An analytic approach that facilitated identification of key patterns within the data without further exploring their casual structure was sought. Therefore thematic analysis was considered most appropriate.

4.5 Methods:

A detailed description of the methods used in the participant observation study is described in the following section. To provide a comprehensive readable account while maintaining anonymity of the research setting, the following conventions were used: (1) The study location was not disclosed, instead, referred to as 'the Trust' throughout the chapter. (2) The contemporaneous field notes and the actual verbatim words of the participants recorded during participant observation were considered to be the key elements of the study. However, all identifiable data were removed from extracts and replaced by an appropriate description (for example, names were replaced by roles; a hospital name was replaced by 'hospital X').

4.5.1 The study context:

4.5.1.1 The study location:

The present study was conducted in a large NHS trusts in the UK. The Trust was formed by the merger of two trusts with a medical school. At the time of the study, the Trust included five hospitals of which three were general acute hospitals with a total of 1500 beds. These acute hospitals provided accident and emergency (A&E), medical care, surgery, critical care, maternity, children and young people's services, end of life care and outpatient services.

The Trust was selected for the present study for three reasons. Firstly, there were already various EP systems operating across the Trusts' hospitals as reported in the national survey. Secondly, as part of a broader strategy of information management, the Trust governance body had decided to procure a single integrated electronic patient record system including ePMA across all sites. Following a scoping exercise, the Trust governance body opted to adapt a commercial integrated EHR system under British Telecoms's local service provider contract with NPfIT in the NHS. Finally, ease of access to the Trust.

4.5.1.2 The integrated ePMA system:

The system vendor was an international healthcare information company originating in the USA. The company specialised in providing solutions for hospitals and other medical organisations to integrate and manage all medical health records, prescribing and financial information. The system was a complex customisable platform with solutions that could be tailored, added or removed to be used for a given health system. Therefore the use of the system was likely to vary between different organisations.

4.5.1.3 Description of the events observed by the researcher:

The following section provides context of the main events attended by the researcher. The timeline of the ePMA project events and meetings observed during the present study is displayed in figure 4 - 1.

<u>System review:</u>

The system review was undertaken between 9 and 13 May 2011. The purpose of this stage was to drive the configuration of the entire system in order to come up with a package which would be the core of the system. A selection of staff representing different disciplines within the Trust were invited to participate in this workshop. Each day started with an introductory session providing a general overview of the system and highlighting potential benefits of implementation for the Trust. In the afternoons, several parallel group sessions ran which looked at ePMA, PAS, Clinical Documentation (ClinDocs), and Maternity. Every day ended with an integration meeting involving representatives from all the parallel groups and the vendor representatives to discuss decisions that may affect the other groups. The researcher attended the introductory sessions and ePMA related parallel sessions. There was no observation of any integration meetings as they were exclusive to specific key stakeholders.

<u>Design review:</u>

The design review was organised in a similar way to the system review. The sessions were held between 17 and 21 of October 2011. The purpose of the sessions was to demonstrate the build to end-users in order to validate design decisions taken during system review. However, demonstrations of the ePMA build were found to be insufficient to guide decision making. The working group found the system to be rather complex. Therefore, they were not able to build a sufficient range of the drug catalogue. Consequently, the ePMA team and invited Trust staff ended up making design decision similar to design review week. Consequently, system validation was postponed and an advanced design review session specific to ePMA module was scheduled instead to authenticate ePMA design decisions.

Advanced design review

The session was specific to the ePMA module and ran on the 16 and 17 Feb 2012. The ePMA group and a selection of end-users ran through scripts to demonstrate suggested ePMA solutions after design review. The working group members have identified 90 medications that would more or less capture most of variations of prescribing that had to be evaluated for system validation. They started drafting seven scripts aiming to incorporate all the 90 drugs identified in seven patients' scenarios. Only two scripts (respiratory and surgery) were drafted and ready for demonstration at advanced design review. In addition, not all of the data collection worksheets (DCWs), design decision matrices (DDM) and order entry formats were completed. This made the whole evaluation process complicated. The group had to make

design decisions rather than reviewing. This was similar to what happened in design review week.

The ePMA group were informed that unlike other systems builds, e.g. PAS, the ePMA system build would be unlocked after the testing period as locking prescribing is attributed to high clinical risk. Hence, the ePMA group had some flexibility in changing their decisions after system validation and testing. However, some elements of the build were to be locked as they were shared with other systems build. Therefore, the ePMA group shifted their original plan from building a simple system to working towards having a more complex system since there would be more time for design. At the end of the advanced design review session, it was concluded that finalising all the seven scripts for system validation was unrealistic. The team agreed to fine tune scripts one and two and complete the related build. They also suggested integrating as many drugs as possible from the rest of the scripts for the purpose of system validation if feasible.

Electronic Prescribing and Administration Special Interest Group meeting:

The electronic prescribing and administration special interest group (SIG) was established in March 2010 and reports to a regional Stakeholder Group which oversees the wide operation of the system adoption within the London Program for IT (LPfIT). The group members consisted of 17 trusts from across the UK. Of these, one trust had already gone live with the system and five trusts had plans to go live by end 2012. Trusts representatives included a mixture of pharmacists, IT specialists, administrative staff, and other

healthcare providers. There were also representatives from BT, and the vendor. The purpose of the SIG group was to assist acute hospital clients in implementing, maintaining and developing the ePMA functionalities by collaborating, providing advice and decision making into the governance structure residing within the LPfIT. The collaboration was achieved through sharing information, facilitating communication between the vendor and organisations as well as supporting audit research. The researcher observed a meeting held on May 2012. The aim of the meeting was to review the SIG group membership, terms of reference, and the scope of the group. Although, the majority of the attendees were happy with the membership variety, one trust representative felt strongly that trust IT staff should not be involved in this group. The representative suggested exclusive membership to end-users with healthcare backgrounds. However, the suggested request was not approved by the group as other members felt that collaboration between clinical and IT was vital for the success of such projects. The SIG group agreed to create speciality groups within the SIG to provide expertise in specific areas. Examples of the suggested groups were drug catalogue, clinical pharmacy, pharmacy verification and rule library groups.





ePMA: electronic prescribing and medicines administration, SIG: ePMA special interest group

* System and design review weeks included events of the overall EHR implementation project. Shared introductory sessions and specific ePMA sessions were observed.

** Advanced design review was specific to ePMA

*** Some of the ePMA working group and stakeholders group were observed.
4.5.2 Data collection:

Access to the events was approved by the Trust and the chairs of the ePMA project team. The members of the ePMA project team were aware about the researcher's role as an observer and the purpose of the study. Participant observation was conducted between May 2011 and June 2012 on a part time basis. The researcher intended to attend all the main events related to ePMA project. However, due to logistics only the following was observed: system review, design review, advanced design review, and some of the meetings related to ePMA project (Figure 4 - 1). In total there were 17 episodes of observations with approximately 60 hours of contact. Observations were supported by reviewing other documents such as agenda, minutes, and information published on the Trust intranet to establish the project timelines and structure. Initially field notes were recorded contemporaneously. The researcher maintained a diary and recorded jotted notes during the observations. These notes were then expanded to detailed field notes on the same day. The researcher's role initially was an observer as a participant. However, over time the researcher took a more active role in helping with recording minutes of the ePMA working group meetings. As a result, the jotted notes were sometimes recorded after observations. Due to personal circumstances, the researcher has to exit the field in June 2012.

4.5.3 Data management and analysis:

Detailed field notes were written contemporaneously (expanded field notes were written at the end of each day) and transcribed into Word 2010 (Microsoft®). All detailed field notes were imported to NVIVO 10 software (QSR International®) which was used to organise the data. The thematic analysis was carried out through the following stages:

1. Data familiarisation: The initial familiarisation stage began while writing the detailed field notes. These were read and initial ideas and thoughts were noted by the researcher. Also thoughts and ideas developed through the observation process itself were noted in a logbook by the researcher.

2. Coding: The field notes were read over and over allowing full immersal in the data and an extended list of initial ideas was developed. Field notes were then coded using NVIVO. The coding was an iterative process that involved a series of refinements based on intuition, logical conceptualisation, understanding and prioritisation. In some cases statements were given more than one code.

3. Identifying the themes: The data were reviewed again to search for patterns. The codes were then grouped into broader potential themes. The full set of themes was then drafted into a preliminary map that described all of the codes.

4. Reviewing and refining the themes: The researcher reviewed and refined the key themes emerged from the data. This was then reviewed by two PhD supervisors (NB, BDF). 5. Labelling the themes: At this stage the themes were clearly articulated, and the titles of the themes had been selected to reflect their meaning.

6 Reporting the Findings: The final stage of the process described above involved reporting the main themes accompanied by relevant evidence. For the purposes of this thesis only the most relevant field note extracts have been included.

4.5.4 Ethics:

The present study was classified as service evaluation and obtaining NHS ethics approval was not required. The service evaluation was approved by the Trust and the researcher obtained a licence to attend the Trust. Ethics application was approved by the School of Pharmacy, University of London (now UCL School of Pharmacy).

4.6 Results:

The results section below is divided into two parts. The first section provides a descriptive account of the study context obtained from observations, informal communication with stakeholders involved, and reviewing ePMA related documents. This section includes a description of the project scope, timeline, governance structure, management methodology as well as the ePMA stakeholders. In the second section, findings are organised into the key central themes that emerged from the field notes and observations.

4.6.1 Project management framework:

4.6.1.1 Scope and timeline of the project:

The business mapping and the contractual agreement of the implementation project at the Trust was conducted in early 2011. The vision of the Trust was to have a stable system within two - five years. The proposed implementation project was scheduled to deliver several elements of the system over two phases. Phase one consisted of PAS, clinical documentation, care planning, maternity, information dashboards (MPages), interfaces for bedside devices (e.g. foetal monitoring) and ePMA which is the focus of the present exploratory work. It had been suggested by one of the ePMA chairs that the pilot phase might be in one of the Trust hospitals. A specific inpatient ward would be selected for the pilot followed by a rapid roll out either to other wards at the same site or same clinical areas across sites. However, the roll out plan remained a matter of debate as the nursing department were in favour of a whole roll out 'big bang' to avoid having hybrid nursing processes and workflows.

Figure 4 - 2 shows the initial and the updated timeframe of the ePMA project in the Trust. The initial plan was to deliver the first part of the Trust data to the vendor by the 13th of July 2011. As illustrated in figure 4 - 2 the timeframe of this project was delayed by almost a year. This was partially because of delays experienced in the delivery of the order communications project due to unexpected issues arising during testing. In addition, at design review week, it was clear that the process was perceived to be more complex than expected and so the build was not completed for the purpose

Page 148 of 305

of design review. Therefore subsequent events were postponed to complete

the system build.

Figure 4 - 2: Initial and updated timeframe of the trust implementation process

Initial timeframe of the Trust implementation process:



Updated timeframe of the Trust implementation process: (January 2012)



4.6.1.2 The project governance structure:

The structure of the project governance at the Trust was perceived to be complex. A simplistic diagram of the governance structure is described in figure 4 - 3. There were six working groups that were involved directly in the build of the system in the Trust. These groups usually consisted of

representatives of the specific clinical or administrative area, vendor representatives, and representatives from the change team as well as the training team. The change team and the training team were primarily Trust teams who were involved with the overall project in the Trust. The change team oversaw the whole project in the Trust and was involved in mapping the processes and monitoring the progress of work. The training team was involved in all the working groups as they needed to understand how the system works in order to be able to develop training manuals, guides and arrange training sessions for all end-users. Each working group reported to a steering group chaired by senior staff. Each steering group monitored the overall progress of their respective working group closely and resolved any issues. The Trust board oversaw the implementation, managed all the groups through a middle management structure and was responsible for higher level Trust-wide decisions. Establishing the structure of the project governance was challenging. There was no published information about the exact governance structure. Figure 4 - 3 was drawn from documents and minutes collected by the researcher as well as informal conversations with the ePMA group members. Most of the members were aware of the working groups, the steering groups, and the Trust board. However, no one was sure about the exact structure of the middle management body and where IT was positioned within this structure.

Figure 4 - 3: The structure of the system implementation governance at the Trust



Training team and Change team: Trust staff. Working groups & steering group members: representative of the relevant clinical area, Vendor representatives, training and change team representatives, other guests on ad-hoc basis. PAS: patient administration system; Clin-Docs: clinical documentation.

4.6.1.3 Project management methodology:

The deployment of the integrated EHR system in the Trust was planned to be completed under the 'Method M' model. This methodology was developed by the vendor to assist clients in governance and planning as well as providing guidance throughout the process of decision making and implementation. The company supports access to tools such as Method M® online which allows clients to document and monitor the progress of the implementation project.

Figure 4 - 4 shows the detailed steps of this model. The model starts with client executive sessions to demonstrate the system capabilities followed by project preparations. At the stage of project initiation, clients will be contractually committed to the project. The next steps are extensive meetings between the client and vendor team to build the system. Clients will then decide on the specifications of the system they deem appropriate for their use at 'system review'. The vendor team will then build a part of the system enough to demonstrate part of the design at 'system design review'. The system build will then continue allowing majority of the build to be authenticated at 'system validation review'. The system will then be tested allowing a chance to make any final necessary changes. End-users will then be trained before the system goes live.



Figure 4 - 4: The 'Method M' project management model

Source: This figure was obtained from the Vendor

4.6.1.4 The ePMA group (the stakeholders):

The ePMA group focused mainly on EP and medicine's administration and all related aspects of the system build. Their work involved essentially compiling three sets of documents shown in figure 4 - 5. These sheets defined the build and the core functionalities required for prescribing and medicines administration. The ePMA steering group was co-chaired by the chief of service for pharmacy and therapies and a consultant paediatrician. Members of the ePMA steering group included representatives from different disciplines like nursing, pharmacists, doctors, IT, vendor representatives, project manager, the change team, and the training team. The ePMA working group reported to the ePMA steering group and it included pharmacists, a nurse, vendor representatives, and the project manager. The ePMA working group met on a regular basis to do all the system build and design decisions. The working group made very detailed notes on their progress. The notes were shared with the steering group every two weeks. They also compiled testing scripts to demonstrate the work done for feedback by end-users at design and system validation.

Figure 4 - 5: Documents compiled by the ePMA working group

Data CollecttionTrueWorksheets (DCWs)CatPick lists thatMat

supporting EP & administration

Trust drug catalougue Medication lists Design desicion matrix (DDM) Process

EP: electronic prescribing.

4.6.2 Key themes emerged from the observations:

The observation findings revealed key themes related to the whole implementation project in the Trust and some themes specific to ePMA aspects. Figure 4 - 6 demonstrates the mapping of the key themes identified in the present study.





ePMA: electronic prescribing and medicines administration.

4.6.2.1 Overall project:

This section describes key themes related to the overall integrated EHR system implementation.

a. Project management:

As described in earlier sections, the Trust had clearly defined the scope of implementation which included integrating a large set of the clinical processes into the EHR. Hence, there were various parallel working groups each responsible for building a specific aspect of a whole system. As a result, a complex project management framework was required to conduct all aspect of implementation. However, individual staff were not very clear about the exact structures and processes within the project management framework.

The stakeholders had to deal with a lot on uncertainties during the project.

For instance, the pilot location and roll-out procedure were not established.

The ePMA team was not clear if discharge was in scope for this stage of the

build. Moreover, the timeline of the project implementation shifted due to

some challenges with completing the build as well as some technical issues

when the order communication module went live.

'After being away for 3 weeks I [the researcher] attend one of the ePMA meetings at [site x]. I [the researcher] had a chance to catch up with [the project manager] in the corridor before the session. I asked him if the plan was still to pilot in the [ward] in hospital B. The project manager said: Nobody knows! We wanted to pilot in a ward in hospital B and have a fast rollout but nurses are not happy with that. They are in favour of a big bang! They want all their staff to be working the same way'

Field Note, working group meeting

During events organised by the vendor, trust representatives seemed to be overwhelmed by the system demonstration. This may have been partially related to the complexity of the system but also because the system was new to the audience. The audience were very attentive to minute details on the screen which were specific to the US domain. Sometimes the chair of the ePMA had to interfere and drive the demonstration instead of the vendor to keep members focused on the bigger picture and not get distracted by irrelevant details.

'Some of the Trust staff expressed concerns about the alerts firing during demonstrations. The ePMA chair explained that the system demonstrated was a US system and they chose to set it up this way. She asked the staff to ignore these alerts for the moment as the decision will be down to the Trust on what alerts to activate'

Field note, system review

b. Staff engagement:

On the whole, there was a broad representation of end-users in the events

organised by the vendor. However, representation was not consistent from

day to day and varied between events. One possible explanation was that

staff had no protected time to attend these events.

'I met [Nurse] again on day 4 of system review week. We had a chat over coffee break. She mentioned she wasn't able to attend the day 2 and 3 because she had other commitments [shifts] in the Trust'

Field Note, system review

Lack of comprehensive staff representation at some of the events influenced

the progress of the project. In some cases, there were not enough decision

makers in the meetings or sessions were chaired by staff who are not

familiar with the matters discussed.

'the vendor representative demonstrated some design solutions related to patient group directions (PGDs). The session lead [a consultant rheumatologist] seemed to be not familiar with the concept and process of PGDs. The audience were not able to make many design recommendations as it turned out there were only few nurses and pharmacists apart from ePMA team who were involved in the build'

Field note, design review

Although the ePMA steering group membership included a variety of staff from different backgrounds, only some people attended the meetings on a regular basis.

'there were the same people [steering group members] in the meeting room as usual. There are many people who only I knew by name [from the apologies list in the minutes] but I haven't met yet'

Field note, steering group meeting

Moreover, nursing representation at ePMA was limited. Only one nurse was actively involved within the group. In many occasions, the ePMA team had to arrange specific demonstrations to nurses or doctors to obtain sufficient feedback.

c. Communication:

A gap in communication appeared during interactions between the vendor and the Trust during demonstrations. Some of the Trust representatives perceived early that terminology used by vendor was vague. Key Trust stakeholders had to interfere repeatedly during the demonstrations to clarify some of the expressions used by the vendor to enable them to understand the system.

'The vendor representative was explaining potential changes in the system and mentioned that phrase 'code'. The ePMA chair interrupted the session and asked if everyone in the session understands what 'code' means. A few participants replied 'NO'. The ePMA chair requested the vendor to explain the different levels of system changes 'code, configuration, and UK enhancement'. In other words, things that could be changed locally, things that couldn't be changed unless a new upgrade from the vendor was purchased and things that would affect the system users on the national level if changed therefore require global consultation with other users'

Field Note, system review

Furthermore, vendor representatives sometimes did not alert audience when demonstrating US based domain or solutions that were not included in the Trust contractual agreement.

'After continuous intravenous infusions (CIVI) demonstration, a nurse questioned the way functionality worked. A member of ePMA group explained that the functionality was demonstrated from a US domain and the Trust build was not ready yet. The Nurse replied: Why on earth did we spend a whole afternoon on CIVIs if the administration part is not fit for purpose?'

Field notes, design review

Integration meetings were not free from communication issues. It was reported that not all the working groups of the project were effective at communicating overarching decisions at the integration meetings. Therefore, there was not enough overview of how much overlap between system builds the working group had.

The Trust built formal and informal channels with trusts implementing the same system to share knowledge and expertise. Membership in the SIG allowed collaboration with other NHS trusts. Moreover, Trust representatives visited another UK trust which had already implemented the system to see how the system worked in real life.

d. Expected challenges:

The high volume of workload in relation to clinical care and massive medical records for patients were identified as one of the challenges the trust might face. It was reported that about four million patients receive their care in the Trust; of these about 250,000 have duplicate healthcare numbers with a maximum of 59 different numbers per patient. The NHS number was selected to be the only single patient number used in the new system. It was

apparent that a lot of work would have to be done to unify duplicate patient numbers and transfer all the records electronically.

Staff had concerns about hardware requirement for the new systems. They realised that fixed computers in patients' bays, computers on wheels, and tablet computers will be necessary to support the new work processes. However, such equipment is expensive. It was uncertain if the Trust had planned to survey available hardware and estimated future needs. Moreover, Wi-Fi coverage was highlighted as an issue in some of the hospitals. For instance, Hospital C had many areas with blind Wi-Fi spots and weak signals due to the old building structure. Solutions to Wi-Fi signals had to be resolved before rollout.

4.6.2.2 The ePMA project:

This section presents key themes related specifically to the ePMA project.

a. Teamwork:

Overall there seemed to be a great teamwork and relationship between ePMA members, including the vendor representative. The group members met on a regular basis to carry out the technical build of the system either in the Trust or at a venue hired by the vendor. This style of working was very different to some other modules' working groups which preferred to have a clear distinction between tasks carried out by the trust staff and the vendor representatives.

'Along with a pharmacist, I attended some of the sessions demonstrated by maternity. The dynamics of the maternity group was so different to how ePMA works. I felt there was a clear distinction between the trust staff and the vendor whereas in ePMA it felt like a one team. Trust and vendor were taking turns in speaking and demonstration and the relationship was very

formal. I discussed that with the pharmacist after the session and she said that ePMA works as one unit. She also said that the vendor representative at ePMA was criticised for being too close to them [the trust staff].

Field notes, maternity group meeting

b. Staff changes:

There were several changes in the ePMA team members that affected the team resources. The ePMA project manager left his role therefore, a new person took over. The ePMA team had fewer resources as the new project manager was managing another module working group simultaneously. At a later stage, a senior pharmacy lead retired and her colleague stepped up to resume her responsibilities. However, that person left a knowledge gap as she had an extensive experience in paediatrics and neonates. At the end of the observation period, the team were in the process of recruiting more staff to compensate for the reduced resources.

c. Documentation:

It became apparent that unlike other modules, ePMA module decisions were not uploaded on to the Method M tool as only one member of the ePMA working group had training and access to the tool. Alternatively, these decisions were documented in minute format following each meeting. The difference in the documentation approach of the ePMA group had a negative influence on communication between the ePMA group and other working groups as well as the vendor. In some occasions, some ePMA related recommendations were not carried out because they were not uploaded on to the Method M tool. Moreover, integration points between the ePMA group and other groups were not communicated effectively. Furthermore, it was hard for the ePMA group members to remember previous design decisions

taken.

'[Change team leader] queried the documentation approach of the ePMA. group She said that design decision matrix [DDM] decisions and design recommendation should be on the Method M. Design recommendation needs to be shared with other groups and the vendor by uploading them on method M. These decisions should capture where these decisions were made and by whom. [A member of the ePMA group] said that vendor and project manager only have access to the tool. [The ePMA] chair suggested that all the ePMA working group members should obtain access and training to use the tool'

Field notes, advanced design review

d. The ePMA design principles:

As described in earlier sections, the ePMA group were responsible for

completing three sets of documents used in building the system. The working

team built and demonstrated a representing sample of ePMA scenarios to

authenticate design decision by end-users.

'the co-chair asked pharmacists to select about 90 medicines representing most scenarios [to demonstrate various routes, dosage forms and similar], build them and demonstrate how prescribing may work to sign off by endusers'

Field note, steering group meeting

Drawing from their past experiences with EP, the ePMA group had an organised strategy to tackle the task to be accomplished. First, the group laid out a clear plan for completing the build and maintained a tracked report of the build progress. Second, the ePMA group tackled challenging medicines to prescribe electronically from the beginning. For instance, oxygen, CIVIs, epidurals and variable dosing were high on their agenda. Third, relying on order sets, and care sets in most of the prescribing build to reduce key strokes and potentially improve safety. Finally, minimising customisation of the drug catalogue and running a report to estimate back-office support required after implementation.

4.7 Discussion:

4.7.1 Interpretations of the main findings:

The above analysis showed that the process of implementing an ePMA integrated into an EHR was extremely complex. The ePMA module was one of many modules being built in semi-isolation. A shared understanding of how other modules work was crucial. However, due to the complexity and large scale of operation, this was not attainable. Module sessions during demonstrations ran in parallel so end-users had to be selective in events they attended. Moreover, staff had no protected time to attend therefore engagement was inconsistent and sometimes limited. Integration meetings were hampered by breach in communicating integration issues. Documentation of ePMA design decisions outside the Method M tool may have contributed to communication issues. As a result of all of the above, the ePMA group had little insight into the rest of the project and some of their design recommendations were delayed and/or not operationalised. Moreover, there was inability to recall past decisions and other key information in some instances.

The study revealed that differences between UK & US terminology and processes affected communication between the Trust and the vendor as well as the progress of the project. The Trust staff were seemingly overwhelmed by the new system presented to them. The vendor representatives were sometimes not skilled in driving demonstrations or highlighting key information required.

The ePMA team had to deal with a shifting project timeline due to delivery delays and technical challenges in other modules of the system. There were also many uncertainties in essential project related decisions such as the 'go live' strategy or project scope. One of the advantages of the ePMA group over other modules was developing strong relationships and teamwork. However, they had to deal with reduced human resources and staff changes through the project.

The ePMA group developed a clear traceable working strategy. Drawing from past experiences, they identified key design principles to facilitate the build, improve user experience and ensure patient safety.

4.7.2 Strengths and limitations of the present study:

A strength of the current study was the ability to obtain a 'rich' description and in-depth understanding of the research setting through observation. Although findings may not be generalisable, knowledge may be transferrable to similar contexts.

Unplanned exit from the research field and not attending all planned events were two of the limitations of the present work. The researcher may have missed some relevant issues or events that might have been relevant to interpretations of the findings and/or analysis. Another limitation of the current study was potential researcher bias. In participant observation, the researcher serves as the instrument for data collection, and reports his/her understanding of the surrounding context. Hence, the researcher's experiences may affect observation, analysis, and interpretation. Recording detailed contemporaneous notes, not only interesting issues, as well as continuous reflection was one of the techniques used to overcome researchers' bias.

At the beginning of the field work, the researcher was excluded from some of the activities. Exclusion at some point in the research process, particularly in the beginning of field work, is common and likely to resolve over time (Schensul et al, 1999). Therefore it's essential for the researcher to recognise the impact of exclusion.

4.8 Conclusion:

In the present exploratory study, the researcher sought to gain an insight into an integrated ePMA implementation journey at a UK NHS trust. The use of field study approach using participant observation provided an effective means of understanding complex social interactions in the context of systems development and implementation. Understanding of the study context, the project management framework as well as the confounding factors influencing the implementation process was drawn from the researcher experiences and insights during the field study. The present work findings therefore provided a grounded basis from which to continue a further qualitative study about integrated ePMA implementation presented in the following chapter. Chapter 5 Implementation of an electronic prescribing and medicines administration system integrated into an electronic health record in an NHS trust: Stage two - Case study

5.1 Introduction:

As highlighted previously in chapter four, a UK NHS Teaching Trust embarked on the implementation of a hospital-wide EHR with integrated ePMA system. The researcher conducted an exploratory study to understand the context of the implementation (chapter four) and guide a further case study which is now presented in this chapter. The focus of this work was to establish stakeholders' perceptions of the integrated ePMA system implementation journey at the Trust.

5.2 Aim and objectives:

This present study aimed to examine the process of an integrated ePMA system implementation using an in-depth case study in an NHS trust. The objectives of this study were to:

- Explore the motives behind implementation of an integrated ePMA system at the Trust
- Explore stakeholders' perceptions of factors to be considered when selecting a system.

- Establish stakeholders' perceptions of elements that influenced the implementation process of the integrated ePMA system at the Trust.
- Describe the challenges faced by the ePMA project stakeholders during the implementation journey.
- Identify key principles and design principles developed by the ePMA group to drive the software build and eventually influence safety.

5.3 Methodology:

The following section provides grounding for the use of a case study approach as well as the methodological aspects taken into account when planning for the present study. The methodology section is then followed by a detailed description of the specific methods applied by the researcher.

5.3.1 Case study research

The case study methodology was developed in social sciences (Robson 2002; Stake 1995; Yin 2003), and is arguably the most common qualitative method used in information systems research (Myers, 1997). There are various definitions of case studies but all agree that a case study is a method aimed at studying contemporary phenomena in their context (Robson, 2002; Stake, 2005; Benbasat et al, 1987; Stake, 2005). Yin defines a case study as:

'empirical enquiry to investigate a contemporary phenomenon in real-life context, especially when the boundaries between phenomenon and context are not clearly evident'.

(Yin, 2003)

Stake (2005) adds that a case study often focuses on experiential knowledge of a certain case and closely related social, political influences. Robson indicates it is a research strategy and stresses the use of multiple sources of evidence (Robson, 2002). Benbasat et al. (1987) provided a more specific description by mentioning information gathering from several entities (people, groups, organizations), as well as the lack of experimental control.

Yin adds to the characteristics of a case study the following:

"copes with the technically distinctive situation in which there will be many more variables than data points, and as one result

relies on multiple sources of evidence, with data needing to converge in a triangulating fashion, and as another result

benefits from the prior development of theoretical propositions to guide data collection and analysis."

(Yin, 2003)

Yin described three types of case studies (2003). First are exploratory case studies, which Yin defines as studies used to explore situations in which the intervention being evaluated has no clear single set of outcomes. The case study methodology was originally used primarily for this purpose. The second type is descriptive case studies which are used to describe an intervention or phenomenon and the real life context. Finally, case studies could be used for explanatory purposes. This type of case studies seeks to answer a question that sought to explain the presumed causal links in complex real life interventions.

According to Klein and Myers, (1999) a case study could be positivist, critical and interpretive depending on the research perspective. Klein and Myers state that a positivist case study searches evidence for formal propositions, measures variables, tests hypotheses and draws inferences from a sample to a stated population. They described a critical case as a study that aims at social critique and at being emancipatory. An example of this type would be studies identifying different forms of social, cultural and political factors that may hinder human ability. Therefore case studies aimed at improvement may be seen as critical. An interpretive case study attempts to understand phenomena through the participants' interpretation of their context. The present study aimed to gain an in-depth understanding of the implementation journey of an integrated ePMA system in the context of a UK NHS trust. The study was influenced by a priori issues identified from the literature and the findings of previous exploratory work conducted in the research setting (chapter four). The researcher aimed to understand the stakeholders' perceptions of the context and the implementation journey. Therefore, the use of an interpretive case study approach was considered appropriate.

5.3.2 Data collection approach:

There has been a long standing debate about the validating function of triangulation in qualitative research (Ritchie and Lewis, 2003). First, from an ontological perspective, there is no single reality or conception of the social world to ascertain. Therefore, some authors argue that attempting to do so through different methods is futile. Second, from an epistemological point of view, all methods have specificity for the data they yield. Therefore several methods are unlikely to generate perfectly concordant evidence. As a result of the above mentioned concerns, some authors argue that the value of triangulation lies in extending understanding or adding breadth or depth to analysis (Fielding and Fielding, 1986).

Page 169 of 305

As described above, case studies rely on multiple sources to obtain data which enhance their credibility (Yin, 2003; Patton, 1990).Data collection methods such as interviews and participant observations may be used for gathering data in case studies. Other sources may include, but are not limited to, document studies, literature reviews and archival records. Although using multiple data collection sources is an opportunity to add rigor, this approach leads to gathering an overwhelming amount of data which could be a potential downside. Therefore effective management of data is essential to prevent researchers from being lost in the data (Yin, 2003; Stake, 1995).

Previous exploratory work using participant observation provided grounding for the present work. Interviews were selected as the main data collection method for the present study. Interviews were further supplemented by reviewing a range of relevant documents such as minutes, agendas to track the implementation of project milestones and changes of the project team over time. Moreover, reviewing the documents allowed the researcher to understand some issues raised by the interviewees during interviews.

Interviews:

Interviews are one of the most common data collection methods in social research. As discussed previously in chapter three, there are essentially three types of research interviews: structured, semi-structured and unstructured (Bryman 2001; Ritchie and Lewis, 2003). Semi-structured interviews are the most frequently used interview type in healthcare research (Pope and Mays, 2006). The flexibility of this approach allows for the

Page 170 of 305

discovery of issues that are important to participants but may not have previously been thought of by the interviewer yet also provides participants with some guidance on what to talk about. In the current study the researcher had a priori issues to explore guided by a theoretical framework which was influenced by previous exploratory work in the research setting. Therefore the use of semi-structured interviews was selected for the purpose of this study.

5.3.3 The theoretical approach:

Evaluating technology in healthcare setting:

The process of adopting new technology has been studied extensively in the literature. There is a growing recognition of the importance of evaluating the social and organisation context in which technology is implemented (Cresswell & Sheikh, 2014). An account of the theoretical frameworks considered for the present study is described below:

A. Donabedian's Structure, Process, Outcome Model

This model was developed for evaluating quality of care and is one of the dominant frameworks in the quality of care area (Donabedian, 1997). It's based on the three concepts of structure, process and outcome. This model has been criticised for failure to incorporate environmental and social factors (Coyle & Battles 1999) as well as the very linear relationship between the three concepts (Mitchell et al, 1998) which led to the development of several adaptations addressing these concerns. Examples of the Donabedian's 'structure, process, outcome' model adaptations include Lilford's and Cornford's adaptations (Brown and Lilford, 2008; Cornford et al, 1994).

B. Cornford's socio-technical framework for evaluating information systems

The Cornford's socio-technical framework was developed to evaluate work within the area of information systems and health policy analysis (Cornford et al, 1994). It is based on the three concepts of structure, process and outcome. The three concepts are then applied at three main levels, the system's functioning, human and user perspectives and the overall impact on the healthcare system. The strength of this approach is that it was developed for the context of healthcare and incorporates both social and technical aspects.

C. Sittig and Singh Eight dimensional model for health Information Technology:

The above model was designed to address the sociotechnical challenges involved in design, development, implementation, use and evaluation of HIT within complex adaptive healthcare systems (Sittig and Singh, 2010). The dimensions of this method are:

- 1. Hardware and software computing infrastructure.
- 2. Clinical content.
- 3. Human computer interface.
- 4. People.
- 5. Workflow and communication.
- 6. Internal organisational policies, procedures and culture.
- 7. External rules, regulations and pressures.
- 8. System measurement and monitoring.

The key to this model is how the eight dimensions interact and depend on one another. Therefore, they must be studied as multiple interacting components with non-linear, emergent, dynamic behaviour.

D. Rogers' diffusion of innovation theory:

A widely used theoretical framework in the area of technology diffusion was described by Rogers' book, Diffusion of Innovation (2003). Rogers postulates that innovations or technology offering higher relative advantage, compatibility, simplicity, trialability, and observability will be adopted faster than other innovations.

E. The diffusion of innovation model for complex innovations in health service:

Greenhalgh et al. (2008a, b) used a multi-level model to evaluate the summary care records early adopters program. This model was developed previously by the same team in a systematic literature review that drew from Rogers' work and other theories published in this area (Greenhalgh et al, 2004). The above mentioned analytical framework considers the dynamic interaction between nine different components (Table 5 - 1). These components included aspects related to the implementation process, communication, adopters' previous experiences with technology and the material properties and attributes of the technology adopted.

The present study aims to explore issues related to the implementation journey of an integrated ePMA system. Therefore, frameworks which focus on assessment of technology outcomes such as adaptations of the Donabedian's model as well as the Sittig and Singh model were not appropriate. Drawing on findings of the exploratory work presented in

chapter four, the diffusion of innovation model for complex innovations in

health services developed by Greenhalgh et al. (2008a, b) was adapted and

used as a framework for the current study.

Table 5 - 1: Components of the diffusion of innovation model for complex innovations in health services developed by Greenhalgh et al

1. Material properties of the technology To be successfully and widely adopted, a technology must include key functionality and work smoothly and efficiently under real conditions of use 2. Attributes of the technology as an innovation To be successfully and widely adopted, a technology must be seen by potential adopters as having Relative advantage (that is, clear benefits over existing technologies) Simplicity Compatibility with existing values and ways of working Trialability (can be tried out on a limited basis "without obligation") Observability (benefits can be seen directly) Potential for reinvention (capacity for users to customise and adapt it) 3. Concerns of potential adopters Adoption is a process, not a one-off event, and is influenced by concerns, including Before adoption—what are its properties and potential benefits?; what will it cost me? During early use—how do I make it work?; when and how should I use it? During established use—how can I alter or improve it? 4. Communication and influence A person's decision to adopt an innovation is influenced by · Mass media (press, mail shots), which can raise awareness Interpersonal influence (by champions, opinion leaders, for example), which can change people's attitudes towards adoption 5. Organisational antecedents for innovation Organisations may be more or less innovative. Differences are explained by several factors: Absorptive capacity for new knowledge Leadership and management Risk taking climate Effective data capture systems Slack resources 6. Organisational readiness for innovation An organisation must be "ready" for a specific innovation. Readiness includes Innovation-system fit Tension for change Balance between supporters and opponents Specific preparedness 7. The implementation and routinisation process Implementing a complex innovation, and making sure it becomes business as usual, is a highly non-linear process, typically characterised by shocks and setbacks. Critical success factors include Appropriate change model (balance between "make it happen" and "let it emerge") Good project management Autonomy of frontline teams · Human resource factors, especially the selection, retention, continuity, and training of staff Alignment between new and old routines 8. Linkage Innovation is more likely when there is Early and ongoing dialogue between the developers of the innovation, the change agents charged with promoting its adoption, and the end users Communication within the organisation and between similar organisations 9. The wider environment Innovation in organisations is more likely when a "following policy wind," a conducive socio-political climate, and specific incentives and mandates at national level are present

Source: Greenhalgh et al. BMJ 2008; Introduction of Shared Electronic Records: Multi-Site Case Study Using Diffusion of Innovation Theory

5.3.4 Data analysis approach:

The objective of analysis is to derive conclusions, keeping a clear chain of evidence, enabling a reader to follow the derivation of results and conclusions from the collected data (Yin, 2003). This means that sufficient information from each step of the study and every decision taken by the researcher must be clearly presented. The methods broadly considered for the analysis were:

Grounded theory:

This is by far the most widely used and influential method in qualitative research (Bryman 2001). However, it is less commonly used in healthcare related research. Grounded theory was developed by Glaser & Strauss (1968). In this method theory is derived from data collected systematically and analysed through the research process. It is a rigorous procedure which involves repetition of data sampling, analysis and theory development until saturation is reached. The process could be time consuming and challenging to perform. Moreover, it may not take into account existing knowledge in complex and/or already relatively well researched areas.

Thematic analysis:

As described in previous chapters, thematic analysis is a qualitative analytic method used for identifying, analysing and reporting patterns (themes) within data. This method attempts to identify specific types of phenomena but not to identify their underlying causal structure (Boyatzis; 1989). It is widely used yet rarely acknowledged (Braun and Clarke; 2006). The advantages of this

method over grounded theory are that it's less complex, more flexible, relatively easy to conduct, and if done well, may offer reliable results.

Framework analysis:

As described in earlier chapters, framework analysis was developed by Jane Ritchie and Liz Spencer, from the Qualitative Research Unit at the National Centre for Social Research in the UK, in the late 1980s for use in large scale policy research (Ritchie and Lewis, 2003) but is increasingly used in other research areas. The framework analysis approach is not aligned with a particular epistemological, philosophical, or theoretical approach therefore can be adapted for use with many qualitative approaches that aim to generate themes (Gale at al., 2013). In framework analysis, data are organised in a matrix based format allowing researchers to compare within and between cases while retaining the context (Ritchie and Lewis, 2003). It also can be adapted for use with deductive, inductive, or combined (deductive and inductive) types of qualitative analysis. Therefore it's ideal for projects with specific issues to explore, but also aims to discover other unexpected aspects of the participants' experience or the way they assign meaning to phenomena. In the present study, the researcher aimed to interview a selection of stakeholders of various backgrounds. An analysis approach which allowed the development of the conceptual framework as well as the comparison between the interviewees' responses while retaining the context was sought. Therefore, framework analysis was considered the most appropriate method for data analysis.

5.4 Methods:

5.4.1 The study location and context:

The present work was an in-depth single case study of an integrated ePMA system implementation in an NHS Trust. As described previously in chapter four, the ePMA system was one of many modules integrated into an EHR to be implemented across a multi-hospital Trust. Figure 5 - 1 summarises the context of the present case study.





ePMA: electronic prescribing and medicines administration.

5.4.2 The conceptual framework

Early insights and understanding gained from participant observation helped plan and shape the semi-structured interview phase. A model developed by Greenhalgh et al. (2008a, b) was selected as a framework for the present study. As described in section 5.3.3, the analytical framework considers the dynamic interaction between nine different components. This framework was adapted for the purpose of the present study resulting in a total of 14 components fitted under five main themes built around the questions sought to be answered (Figure 5 - 2). The five main themes devised by the researcher were: 1. why would a trust introduce/change the system? 2. What system should they choose? 3. What factors influence the implementation process? 4. What are the challenges for change? 5. How to make sure the change is safe?.

The components of the original framework were re-fitted under these five main themes based on logic and insights from previous work conducted (chapter four). Seven components were used verbatim (components: 1, 2, 3, 5, 6, 7, 8. Table 5-1) while two were amended (components: 4, 9. Table 5 - 1). Other additional components were added based on a study conducted by the researcher (chapter four) and the literature (components: 10 -14, and the fifth element under component 7. Table 5 - 2). For instance, the eleventh element of the adapted framework (complexity of the process), and the twelfth element (design principles) were added based on the findings of the previous study presented in chapter four. The tenth element of the adapted framework (loss of organisation memory) was based on wider literature of HIT and organisational research (Kransdorff, 1998; Bate et al, 2008). The framework was amended during the pilot study and early phases of data collection and several iterations were reviewed by the PhD supervisors (BDF and YJ).

Figure 5 - 2: conceptual framework adapted from Greenhalgh et al (2008 a, b)

Theme	Component	Element
Why would a trust introduce/change the system? ^{\$}	1. Internal reasons ^{\$} (Q5)	Advantage over current system used £
		Interpersonal influence (e.g. Champions) £
	2. External reasons ^{\$} (Q5)	Policy £
		Mass media £
What system should they choose? \$	3.Material properties of the system * (Q6,7)	Include key functionality and work smoothly and efficiently under real conditions of use *
	4. Attributes of the technology as an innovation $*(Q6.7)$	Relative advantage (over existing technologies) *
		Simplicity *
		Compatibility with existing values and ways of working
		Trialability (can be tried out on a limited basis "without obligation") *
		Observability (benefits can be seen directly) *
		Potential for reinvention (capacity for users to customise and adapt it) *

* Verbatim taken from the original framework

£ Taken from the original framework and amended (either rephrased or grouped or relocated under a different section)

\$ New addition to the framework

Theme	Component	Element
What factors inflence the implementation process? \$	5. Organisational antecedents for innovation: *(Q3,4,8,13)	Absorptive capacity for new knowledge *
		Leadership and management *
		Risk taking climate *
		Effective data capture systems *
		Slack resources *
	 Organisational readiness for innovation: *(Q9,13) 	Innovation-system fit *
		Tension for change *
		Balance between supporters and opponents *
		Specific preparedness *
	7. The implementation and routinisation process: * (Q3,8,9,10,13)	Appropriate change model (balance between "make it happen" and "let it emerge") *
		Good project management *
		Autonomy of frontline teams *
		Human resource factors, selection, retention, continuity, and training of staff *
		Engagement of the rest of staff \$
		Alignment between new and old routines *
	8. Linkage: * (Q9,11,13)	Early & ongoing dialogue between the developers, the change agents, & end users *
		Communication within the organisation and between similar organisations *

Continued - Figure 5 - 2: conceptual framework adapted from Greenhalgh et al (2008 a, b)

* Verbatim taken from the original framework £ Taken from the original framework and amended (either rephrased or grouped or relocated under a different section)

\$ New addition to the framework
Continued - Figure 5 - 2: conceptual framework adapted from Greenhalgh et al (2008 a, b)

Theme	Component
Challenges for change: ^{\$}	9. Concerns of potential adapters (before, during and after adoption) ^{\$} (Q8,10,12)
	10. Loss of organisational memory (Knowledge degradation) ^{\$} (Q9,12)
	11. Complexity of the process \$ (Q9,12)
How to make sure the change is safe? \$	12. Design principles to ensure safety and reduce clinical risks ^{\$} (Q10)
	13. Should workflow should drive the build or the system build change existing workflows (finding the right balance) ^{\$} (Q10)
	14. Upkeep, maintenance and reporting ^{\$} (Q10)

* Verbatim taken from the original framework £ Taken from the original framework and amended (either rephrased or grouped or relocated under a different section) \$ New addition to the framework

An interview guide was drafted in the light of the study conceptual framework adapted from Greenhlagh et al. (2008 a, b) (Appendix L). The interview guide questions were reviewed by PhD supervisors (BDF, YJ) and then piloted with pharmacists involved with ePMA. The purpose of the pilot was to (1) eliminate any ambiguous or difficult questions, (2) establish if questions give an adequate range of responses, and (3) check time feasibility. During the pilot study, all questions were reworded if found to be ambiguous by the interviewee or if interviewees did not answer as expected during the pilot study. Adjustment to the interview guide was carried out during the interviews if new important issues emerged that were not taken into account previously. The interview guide questions did not constrain the interviews, ensuring that issues raised by the participant were considered. Interviews were audio recorded and transcribed commercially. The researcher checked the accuracy of all transcription made.

5.4.3 Methods for data collection:

5.4.3.1 Sampling:

The study participants were purposively recruited. The proposed number of interviewees was seven to ten. Selected members of the ePMA working group, the ePMA steering group, the Trust board and other key staff were identified during the observation and invited to take part in the interview stage. The categories of the selected stakeholders were: pharmacy representatives in the ePMA working group, members of the change team and the training team involved in the ePMA project, a representative from the

Page 182 of 305

Trust board, representative nurses and medical staff and IT staff involved in ePMA as well as the vendor.

A participant information leaflet explaining the aims and objectives of this evaluation was given to participants (Appendix M) and written consent was obtained (Appendix I). All interviews were conducted face to face and lasted for an average of 45 minutes. Interviews were supported by reviewing the agenda and minutes of the meeting related to ePMA from April 2011 to December 2014 as well as other key documents related to ePMA such as data published in the Trust intranet.

5.4.4 Data management and analysis

NVIVO 10 software (QSR International®) was used to organise and manage data. Interviews were audio recorded and later transcribed by a professional agency. The researcher checked all transcripts for accuracy. The stages of the framework analysis approach were applied to manage coding and analyse the interviews. First, the researcher familiarised herself with the transcripts through continuous reading. Transcripts were coded using NVIVO line by line to identify predefined and emerging themes and subthemes from the raw data (Appendix N). The interview framework was used as a guiding tool to analyse the information gathered from interviews but also any other themes that emerged from the data were taken into account. Emerging codes and themes were then refined by reading and re-reading the transcripts. Coding and stages of themes refinement were reviewed by the PhD supervisors (BDF, YJ). Data were then charted in framework matrices

using NVIVO which were then used for analysis and interpretation. A sample of one of the framework matrices is displayed in appendix O.

5.4.5 Ethics:

The present study was classified as service evaluation therefore obtaining NHS ethics approval was not required. A service evaluation was approved by the Trust and the researcher obtained a licence to attend the trust. Ethics approval was granted by the School of Pharmacy (now UCL School of Pharmacy).

5.5 Results:

5.5.1 Characteristics of the interviewees:

A total of eight semi-structured interviews were conducted between January and September 2014. Participants included stakeholders of various professional backgrounds who were involved in ePMA in different phases. All interviewees were members of the ePMA working and steering groups and three were involved in the actual build of the system. Table 5 - 2 provides a summary of interviewees' professional background, roles and timeframe of involvement within ePMA.

Table 5 - 2: Characteristics of stakeholders interviewed in the	case
study	

Profession	Role in ePMA	Duration of involvement	
Senior pharmacist	Co-chair 'operational'	Project kick off- Nov 2012	
Senior pharmacist	Co-chair 'operational'	Dec 2012-Dec 2014	
Senior doctor	Co-chair 'clinical'	Project kick off- Dec 2014	
Senior pharmacist	Clinical lead	Project kick off- Dec 2014	
Pharmacist	Computer services pharmacist	Aug 2012-Dec 2014	
Pharmacy	Project officer	Aug 2012-Dec 2014	
technician			
Senior Nurse	Nursing lead	Project kick off- Dec 2014	
Vendor	Vendor architect	Project kick off- Dec 2013	
representative			

5.5.2 Overall project timeline and staff involvement in ePMA:

Table 5 - 3 shows the overall timeline changes of ePMA implementation

project events and milestones. The timeline shifted considerably in

comparison to the initial projected timeline due to various technical

challenges that will be highlighted in later sections.

ePMA event	Initial Planned date	Actual date	Other modules go-live
Project kick-off	March-2011	April -2011	
System Review	May-2011	May-2011	
			Order communications module September-2011
Design review	July-2011	October-2011	
Advanced design review		January -2012	
System validation	Oct-11	Mar-12	
			PAS and maternity modules April- 2014
Conversion (go- live)	Apr-12	March 15 (Planned)	

Table 5 - 3: Initial planned and actual dates of ePMA events and milestones

PAS: patient administration system Last update: December 2014

Changes were not limited only to project timelines as staff retention was an issue. There were considerable changes in ePMA stakeholders and other staff involved in the project. Figure 5 - 3 shows tracking of staff involved with ePMA over time. As demonstrated, there were changes in the leadership of the group as one of the co-chairs left the trust end of 2012. The ePMA implementation project had a series of project managers and there were also

changes in the pharmacy team which was involved in the actual build of the system. There were changes in the clinical representation, the change team, as well as the vendor architects. Notably, there was only one nursing representative in the ePMA team. She remained engaged throughout the project. Moreover, meeting minutes review revealed that only a small number of people attended the stakeholders meetings consistently.



Figure 5 - 3 ePMA stakeholders tracking from project kick off until December 2014

Grey colour indicates people involved as guests (e.g. observer, advisor), black colour indicates stakeholders.

5.5.3 Findings:

In the following section, findings are presented as per the study framework.

5.5.3.1 Understanding the motives behind introducing an ePMA system integrated into an EHR system:

The introduction of an EHR and integrated ePMA in the Trust appears to have been a multifaceted decision. Numerous interlinked internal and external factors have contributed to embracing this strategy within the Trust.

a) IT strategy review following the Trust merger:

Following the formation of the current Trust (after the merger of the two former trusts in 2007), there was an opportunity to review and update the trust IT strategy. The two former trusts had two different approaches; one of the trusts had plans to implement an integrated EHR under the national program while the other was still undecided but considering a best of breed approach amongst other strategies.

'It was a strategic decision made by a previous board some time ago, the organisation was only formed in October 2007, I think and at the point the [Hospital A] merged with [Hospital B], [Hospital A] was still thinking about whether to go for the national program for IT or whether to best of breed and other things but Hospital B had absolutely decided on the [system] and they were quite far along in their decision making and the new board decided to adopt the [Hospital B] strategy'

Interview 1, senior pharmacist

b) Concerns about the Trust internal systems:

It was also suggested that some of the internal IT systems within the Trust

were at risk of falling down and/or required replacement in the near future.

The PAS system referred to locally as ICHIS (integrated computerised

hospital information system) was not going to be upgraded. Furthermore, the

use of a paper-based health record and prescribing was considered

inadequate for the future. There were issues with case note tracking due to

duplicate records which may subsequently influence patient safety.

Therefore moving to an electronic system was seen as a logical step to

improve current practice.

'I think the driver is because we have huge issues with case note tracking because of patients with multiple hospital numbers and all of that and going to the single electronics database. It was probably the right thing to do'

Interview 2, senior pharmacist

'I don't think we have got a lot of choice. We have to move away from paper records, the system is fatally flawed, we lose records all the time, we duplicate records, it is cumbersome, there are delays in service whilst you can't access records, it's dangerous not to be able to access records'

Interview 5, senior nurse

C) Benefits of digitalisation and system integration:

It was implied that none of the existing Trust systems at that time were

suitable to roll-out to the rest of the Trust. Hence, there was a need to

procure a new system.

'We did need one system across the Trust and the systems we had, neither Trust had a system adequate to roll to the other so we were going to have to buy new system anyway [......] and it's all about whether people buy into the idea of an integrated system and I think there was a lot of interest in both trusts with the need to integrate and to have systems that talk to each other and I think the clinicians were less interested in which system it was, so much as we just got on and got something. We had been waiting for electronic prescribing for a very long time!'

Interview 1, senior pharmacist

The Trust realised the potential benefits of digitalisation and linking all its

systems. The notion of providing a unified practice across sites and acquiring

an EHR with integrated systems including ePMA was perceived as one of

the key drivers.

'We knew that our own internal systems were in danger of falling down. We knew that ICHIS [integrated computerised hospital information system] wouldn't be supported; we needed to change our PAS [patient administration system] system so it was sensible to change our PAS system that was going to be compatible with the rest of the electronic record, whether that was pharmacy or documentation or anything else, so I think that was inevitable [......]I think the ability to see the entire record in one place is very helpful. So, at the moment we might have nursing notes in a folder over here, medical notes in a folder over here, pharmacy may have their information somewhere else and to actually have all these together and to crosspollinate is very helpful. I think, hopefully, there is also potential to reduce duplication because we collect a lot of demographics and replicate those hugely. I think it is also easier to identify gaps in records because it is clear that something hasn't been completed, which is not so clear in the paper record'

Interview 5, senior nurse

d) Effect of the national IT program, financial incentives:

Stakeholders agreed that national program for IT played a role in the

decision making process and some highlighted that the financial incentives of

joining the program.

'I am fairly certain it was the Trust's view on benefits, but I think the fact that theoretically the software comes free would have been very attractive. So under the London program if you adopt the program at the time you don't pay for the software and so that can represent a considerable saving to a Trust, depending I guess on how much of your other software you need to replace because of the cost of change and everything'

Interview 1, senior pharmacist

'And it is part of a government initiative. There was a very long time where there was a pot of fund given to move to an electronic record and for example, we have already moved to the results being electronic, so as within the organisation you have systems that need to be replaced or renewed or upgraded, there was an opportunity to start looking at a single system, a single way of doing things'

Interview 2, senior pharmacist

e) Reflection of the evolution in healthcare:

The interviewees acknowledged that technology is the way to go forward in

the NHS.

'I don't know if every single hospital is taking on something like this but I imagine for future the technology is the way to go so I just think we are just in that process of getting there'

Interview 7, pharmacy technician

One of the themes emerging from the interviews was that system

implementation in the Trust reflects the evolution of technology in healthcare.

The Trust staff realised that they needed systems to support modern ways of

working.

'Our record system and our prescribing system is the same as a 100 years ago currently, there are huge problems with governance, with all sorts of problems with medical records with their availability, the amount of time it takes, the problem of storage, we live in a world where such systems are pretty ancient now, there are so many things where we don't work like that anymore, sooner or later that's going to have to come to a big healthcare organisation'

Interview 3, senior doctor

".....and I think it just fits with the evolution of healthcare that we need to have more remote working, teleworking, the ability to look at things; a cardiologist could look in hospital A and review something for a patient in hospital B without wasting people's travel time, so I think it has a huge potential and it was inevitable that it would occur"

Interview 5, senior nurse

Interviewees also acknowledged that the Trust was dedicated to pioneer

innovative projects and novel technology.

'There might be, we are like a big academic health science centre, so I imagine we'd want to get involved in anything that is just going to make us better, more streamlined, better services, reporting, all sorts of things, things that we'd benefit from'

Interview 7, pharmacy technician

Page **191** of **305**

'I think also [Trust] does like to champion novel things and try and link that in with research and publication, which I think occurred here, but also there has been an NHS IT strategy, well, for over 20 years that I have been aware of and we have thought electronic records have been coming for 20 years, so I think there have been a number of drivers nationally and locally'

Interview 5, senior nurse

5.5.3.2 Perceptions of the stakeholders about the factors to be

considered when selecting a new system:

a) Benefits over existing systems:

Advantages of the new over the existing system was highlighted as one of

the main aspects considered.

'I think going to an electronic system immediately has benefits because it is readable, the legibility is... I think it doesn't need to show something for us to then go to it, I think it is just obvious that it will give immediate benefits but yes all systems have to justify their expense so they do need to show benefits going forward. I think they are there, the main benefit is standardising and driving better care through standardisation and improvement in prescribing administration'

Interview 2, senior pharmacist

'it has the advantage of being able to come with decision support so for example are you aware you are about to prescribe penicillin to someone who has a documented penicillin allergy, those systems don't really exist in any paper system, you have to rely on other methods to deal with that, so dose checking, interaction checking, many things that can be provided in an electronic system could provide great advantage, legibility not a problem, big problem with a handwritten system'

Interview 3, senior doctor

Predictably, replacing paper-based prescribing by an electronic system offers

an immediate benefit of legibility of prescribing. Other benefits highlighted

during interviews included decision support, standardisation and

improvement of prescribing, as well as return on investment. However,

interviewees pointed out such benefits may not be observed immediately but

are expected over time. Therefore, systems do not have to show immediate

benefits to be adopted. Yet, adopters need to know what are the benefits

expected, when are they likely to be realised and plan to measure those

expected benefits.

'I think you need to actually set a time point when you are going to realise that benefit and I think that comes into, I'm very much in favour of quantifying some measuring benefits before it happens and then comparing this afterwards but then for the post-implementation benefits you need to say what you expect to achieve. So, at what point do you want to see that return on your cash, maybe. So, if you've got something to do with funding, with money, you want to say "at what point do I see this?". You might say "well when we go live" and a lot of the time you say "well I'll have the benefits once the whole Trust is live". If you've got a slow roll-out you are not going to see these benefits, but I think that is the key, is to specify what you think the benefit is, how you are going to measure it and what it needs to be, but also I do believe that you have to combine the benefits of implementing the system with any other service improvement projects that you have got on the go as well, I think it needs to be an overall measurement'

Interview 8, vendor architect

b) User-friendliness:

Simplicity, ease and speed of use were emphasized as important

characteristics to be considered when selecting a system. End-users should

be able to access the system and obtain required information or perform

required tasks in a relatively short time.

'It needs to be user friendly, it's going to be used by pretty much any member of staff so it needs to be easy to navigate, not too complicated looking where you have got lots of things that you might not need. It needs to be quite clear; you want to be able to put information and be able to find it in the right format, you want to be able to send that information to the right people if you need to, if there are amendments that need to be done you need to be able to just use the system where it is not going to stop you from doing things and be able to report out. The whole point is if everything is set up electronically you should be able to pick out any information that goes in, you should be able to take anything that comes out of it'

Interview 7, pharmacy technician

c) Triability:

Interviewees deemed the concept of trialling or piloting an EP system without

commitment unrealistic and impractical due to difficulties and costs

associated with building it.

'Given everything I've said about the difficulties in actually setting up the system to be available for local practice I think that is just either naïve or nonsense, it is unrealistic'

Interview 1, senior pharmacist

However, interviewees suggested possible workarounds such as visiting

similar institutions which implemented the same system. They also

mentioned that speaking to users is fundamental.

'Now that's a difficult one because of the cost, it's very much because of the cost. So, that's why to input something, to say "well we'll trial this on a basis and if we don't like it we can pull it out", that is a very expensive way of thinking so I don't think that would be the answer. I do think the way around that is that before somebody goes in and thinks "I'm going to buy that system", they go and see how it is working elsewhere. [......] they go somewhere else, they go and see, ask, not just "yes, you can come to the supplier and you can get demonstrations and everything", that's fine but you need to go and see how other people use it. That I think is the key and talk directly to the user and what they've seen, what they've had to go through, what lessons they have learned, what would they say, "yes, that's the right thing to do" and what would they say "now I know better I would not have done something that way", and also what do they feel is better now for them and what is worse'

Interview 8, vendor architect

Limitations to viewing systems in other institutions were highlighted. For

instance, the lack of ability to understand the implementation journey as

users might fail to recall what they went through. Moreover, users may

accept systems' limitations over time. Therefore, one might not be able to

sense if a system is limited in functionality or was set up by end-users in a

certain way.

'it is very difficult when you visit other sites, you get this sort of effect that once the system is live people like or don't like it but the memory.... of what you want to get through to get to where you are is lost and people begin to accept the system and so when you are building and implementing you have a real view of what you want driving it and then as you go along you say "oh, I can't have that" and you begin to accept it and when you look at other people's systems you don't really have a sense of whether it is because they designed it in such a way or whether the system is limited to that functionality and what has changed since people did it. It is very, very difficult'

Interview 1, senior pharmacist

d) Compatibility with existing values and ways of working

According to the interviewees, there was a need for some degree of

compatibility between a new system and the workflows of the hospital

implementing it. Nevertheless, system change was perceived as an

opportunity to review and improve outdated practices.

'I also think that existing work flows might not be the current practice so it is also important where, this is the time where you know, we have to review current practice along with what the future will bring and make sure that both are in, whichever one we pick should be the best. I don't think it should be moulded around what we currently do, it should be try and review what we currently do and see if that is best practice'

Interview 7, pharmacy technician

Some interviewees emphasised that a system has to be compatible with high

level value. Nevertheless, workflows and processes may require significant

changes to achieve better results. Arguably, accepting such changes in

workflows requires culture change.

'the values I think, the very high levels so you can maintain your values but I think the processes can be revisited and pulled apart and looked at again and that is a very big challenge because you might have this department who will think "well I've improved what I am doing here" but it may clash with what is happening over here. That's a big culture shift and it is not something you can do quickly'

Interview 8, vendor architect

Page 195 of 305

e) Capacity for users to customise the system:

It was suggested that a system should allow for customisation to suit local

needs.

'you've got the ability and you've got some, what I call, wiggle room, so you can, so it's not a "you have to have this", so there is some ability for whoever, the organisation, to customise what things they can do'

Interview 8, vendor architect

However, significant customisation was perceived to be potentially

problematic as it may hinder the system from moving forward and/or

increase the need for back-office maintenance.

'I think too much customisation may mean that the supplier will not upgrade and move forward with technology. So, we know for this product for this system it is a US based system, and if you customise too much for the UK the development will be out of sync and we may not get the future developments as quickly and the system provider may not, when they develop, do it properly for the UK method of working or ways and we may have more system problems later. So that's the negative why I wouldn't really want to be too customised but there will need to be a level of customisation because the workflow is different for the UK'

Interview 2, senior pharmacist

f) Functionalities to improve safety and quality as well as drive audit

and policy adherence:

Clinical decision support to improve safety and quality of prescribing was

deemed an essential feature to look for in a system. Also the ability to drive

audit and monitor adherence to policy was considered an essential feature.

'It's about efficiently supporting the workforce including some levels of decision support to improve the quality and safety of prescribing [......] very important thing is being able to get data back out, so one of the advantages are to drive clinical audit, to help us monitor prescribing policies, to get closer to prescribing policies'

Interview 1, senior pharmacist

Interviewees believed that despite the limitations of the new system implemented in the Trust, it has the potential to deliver many of the features mentioned earlier. They also highlighted that the end result depends on the way the system is built.

5.5.3.3 Factors affecting the process of implementation at the Trust

a) Organisational anecdotes for innovation (past experiences):

Interviewees reported previous experiences and 'teething problems' due to

EP system adoption in one of the Trust hospitals.

'there was a lot of anxiety prior to its introduction, there was an enormous number of teething problems, a couple of pharmacists pretty much lived on the ward 24 hours a day to begin with and certainly remained on the ward for months in daylight hours but once people really did get into it, they liked it and when it was finally withdrawn because it was a project that came to an end people missed it but I think the teething problems at the beginning were much bigger than anybody had ever imagined and persisted for longer than anyone imagined and also we had significant problems with hardware, access to PCs [personal computers] to actually manage things electronically'

Interview 5, senior nurse

However, stakeholders thought that the present implementation project was much bigger than any project they have experienced so far. Nevertheless,

autonomy of the ePMA group as well as their past working experiences were

an enormous advantage.

'I mean there were three people that were working closely on this, were myself, from pharmacy, myself as the project lead and project chair and then [pharmacist] as the project lead and [another pharmacist]; we had worked together on many other similar projects so we had a very close relationship and a good understanding of how to work projects and the person we worked with at [vendor] had actually previously worked in our pharmacy department, so in terms of relationships that helped in terms of relationships and also helped with style and manner of working; we were able to bring previous experience in'

Interview 1, Senior pharmacist

b) Organisational readiness for innovation:

Interviewees stated that the Trust staff were not prepared for the new

system. Yet, some acknowledged that it may have been very hard to prepare

for the 'unknown'. Some mentioned lack of preparedness in relation to

infrastructure such as hardware and Wi-Fi. Moreover, aspects related to

training, or viewing the system early in the project were also reported.

c) The implementation process:

The ePMA group had to deal with the workload of the implementation project.

'it's too much and it has, I think when you have to deliver to some deadlines it's been quite stressful and it's not just the [system] project that's created stress but then we have other competing projects within pharmacy, for example we are currently procuring our next pharmacy system and that also requires additional time to be dedicated to it, so there have been times when it has been quite stressful'

Interview 2, senior pharmacist

There were issues with amount of, and attributes of, human resources

throughout the project. Examples of these were issues with project

managers, and training team members.

'We've had real problems with resources throughout the pilot. [.....] I think we were lacking in project management support and we had a project, we had a series of project managers, actually, throughout the time but we weren't involved in the appointment of them and some of them didn't have the skill level and attributes that we thought were right for the support that was needed and so while we met some very nice people, there were issues throughout the project in... It's hard to say whether it was the amount of resource, there were certain issues in the quality of the resource and there were issues in the continuity, which caused us significant problems throughout the project'

Interview 1, senior pharmacist

The ePMA group had to acquire new skills such as project management.

'we had to bring on new skills for people. So, for me to explain to the project team that I wanted them to scan a catalogue, count how many drugs and then keep an ongoing report of how close to 80 % [of the drugs build] we were and a change of last [update], again were new skills for the team so they struggled to do the documentation. We needed so many different skill levels to keep this going and so once we got that done you move on'

Interview 1, senior pharmacist

There were also limited representation of end-users, particularly in nursing.

'in relation to administration, I think we've had very few people involved from administration as I said earlier, being the only nurse on the working group has been very noticeable for me and equally I am at a point in my career where I am not walking around a ward pushing a drug trolley dishing out drugs, that's not what I do, so I am applying older experience that may even be outdated to some of the decisions, so that could be an error. We have tried to test some of these things on more junior staff but I think at the end of the day we have tried to be pragmatic'

Interview 5, senior nurse

Moreover, there were issues with retention of ePMA stakeholders members.

As presented earlier, some members had moved on which may have

affected the knowledge and the momentum of ePMA work. Some thought

staff changes may have been beneficial as it brought new views and

expertise.

'I think that every time you lost somebody, you lost somebody that had known what we were doing and you had to start again inducting somebody into the language, into the approach and of course sometimes that's good because they bring a fresh view, but sometimes it just takes some time because you are retraining somebody, bringing somebody else back up to speed and it slows you down and is inefficient in terms of use of time. It breaks the team dynamic and makes people have to restart new ways of working, so it's quite interruptive, it slows the process down and it can be difficult for a team if they have to come to realise the negative attributes of maybe some of the people who have left; it can be a bit demoralising, you have to pick yourself up and keep going but it slows it down, adds cost and time'

Interview 1, senior pharmacist

The ePMA group faced a complex project with shifting timelines as

presented in earlier sections. There were delays in the go-live date of the

ePMA module partly due to technical issues with other modules of the

system.

'I think there has been delays and the delays are that we needed to the PAS [patient administration system] in and the current delays are probably getting agreement about what are going to be our initial go live areas, getting agreement on whether we go live in the inpatient environment or the outpatient environment and getting agreement and buy-in from the Trust divisional units on site by site go live. I think the other concern is going to be that, as we implement, we are going to be in a sort of mixed economy, some services will be electronic in some areas and paper in other areas and there will be a lot of pain and so we need to do it quite quickly so that we are all on the electronic space'

Interview 2, senior pharmacist

Terminology differences between UK and the US were highlighted as one of

the difficulties ePMA group faced.

'I think because it is so complex to do and because people use different vocabularies for the same thing, so you end up with ... a [vendor] have one vocabulary, the same word can mean different things to different people. You have a pharmacy vocabulary, a doctor's vocabulary, a nurse's vocabulary, IT department vocabulary, [vendor] vocabulary, communication can be very, very difficult because it can be hard to understand what people are talking about'

Interview 1, senior pharmacist

Most interviewees acknowledged that terminology evolved and was no longer a big issue as the project progressed. Nevertheless, interviewees agreed that there will be potential challenges when the staff will be trained on the system.

'I think it is just something we have gotten used to. I think initially there was a lot of acronyms and things like that where we didn't really understand what that means but I think the more time we spend with them I think we just become [vendor], we understand their language'

Interview 7, pharmacy technician

Documentation was highlighted as a challenge. Initially, the ePMA group did not use the Method M system to document decisions. Therefore there were complications in communicating decision to the program board and the rest of the project modules.

'but just trying to keep a track of everything was extraordinarily difficult and we were a bit beset at the start by there is a very formal MethodM system but that felt alien and it wasn't an alien and difficult to do and it wasn't clear to us how much of the things that we were discussing were big enough to go on MethodM or not and we were encouraged by our initial [vendor representative] that the things we were doing didn't need to be on MethodM and then we would find that when we went to the program board that things were taken account of because they weren't on program'

Interview 1, senior pharmacist

d) Linkage:

The Trust staff maintained communication channels with other trusts

implementing the same system either through the SIG or informal channels.

Communication and teamwork between the ePMA members was excellent.

Due to the issues raised earlier, communication of the ePMA group with

other modules stakeholders was far from ideal despite the shared ownership

of some aspects of the system. Some stakeholders thought that

communication with the vendor was not optimal in groups other than ePMA.

5.5.3.4 Challenges for system change

a) Complexity

Drawing on issues discussed in earlier sections, complexity of the

implementation project emerged as one of the main themes.

'NHS users are always, always disappointed at what the function actually delivers. The providers are always very keen on telling you what their functionality delivers and it takes some time for meeting of the minds when you realise that you have got to make a start before you can often build in additional functionality and get to a whole understanding of the system because they are just complex, all of them are complex and its very, very hard to understand it and even if you have external resource you do need to rely on your internal resource and free people up because they are the people who know what they need, but they don't understand the vocabulary and they don't understand the way it works'

Interview 1, senior pharmacist

b) Loss of organisational memory

Complexity, challenges in documentation and staff changes affected the

Trust's 'memory'. Interviewees found it very hard to remember certain

decisions or reasons behind a specific system build features due to the

above mentioned factors.

c) Concerns of potential adopters:

Interviewees had various concerns during the project. However, concerns

changed as the project progressed. For instance, terminology was an issue

at the beginning of the project. Similarly, building certain aspects of the

system was a concern that resolved over time.

'Yes, loads of concerns over the time. I had concerns about the quality of the support we have in terms of project management, I had concerns in terms of the quality and volume of the input from [vendor], [....] I was concerned that we didn't understand enough about the system to be making good decisions. I was concerned that we weren't sure we were doing the right things and was concerned that the overall program was so complicated that we couldn't have insight to what other modules were doing and we weren't able to learn from them, really concerned about continuity and how we could keep our staff going and from my staff just the volume of work that they had to do and how they prioritised that and then at times whether the software meant that we couldn't do various things. [.....] I would guess I also had concerns about the software, whether there was enough money for hardware, whether the wireless networks would work, I was concerned about the approach to training.

Interview 1, senior pharmacist

5.5.3.5 The ePMA group working strategy and design principles to ensure safety of the system build

a) The ePMA working strategy:

1. Pragmatism:

The ePMA group have developed a strategy to allow tackling the build of the

system. They selected a representative sample of all scenarios of prescribing

initially. This approach allowed the ePMA group to understand the build of

the system and enabled them to demonstrate potential solutions to end-

users.

'We seem to have attempted to have bite size pieces to deal with and I am remembering back to the first few meetings that we went to, we identified the top hundred drugs for example, or something like that, and tried to deliver those. We tried to make sure that we actually had examples of each administration method so that, for example, have we prescribed eye drops properly because once we can get one right we can get them all right'

Interview 5, senior nurse

Page 203 of 305

The ePMA group were keen on validating design decisions by end-users.

'So we would do the build, we would show back, look at discussions, the Trust may have said "Well we don't want it that way, we want it done this way" and a lot of the time functionality doesn't have the, you know, it won't do what they want it to do so we working, "Well why don't we do this instead", so there was a lot of discussions and decisions, "Right, well how do we get to that point, well, you know we can move on" and make everyone, not happy, ecstatic, but that its safe and fulfils the pathway, the prescribing'

Interview 8, Vendor architect

2. Setting the benchmark:

The ePMA group set from the start a benchmark for building the system. The

system had to be equal to, if not better than, the current paper prescribing

system.

'The fundamental principle is to make a system that is not worse than we have got now. So it was an absolute design decision that if something wasn't perfect, so long as it wasn't worse than we have got now and it wasn't less safe, then even if you walked into the room and expected it to be marvellous you couldn't have it. And, so, not worse was a really big driver,

Interview 1, senior pharmacist

3. Recognising deliverable build aspects 'staying ahead of the game':

The ePMA team prioritised areas which they knew were challenging for

electronic prescribing and tackled them at an early stage of the build.

'we've done our oxygens and insulins and that kind of thing we started trying to work out good solutions for. We also needed some frequencies and some patches that were given every 72 hours and our first doses and that kind of thing was quite important to get right and we started working on that early as well'

Interview 2, senior pharmacist

The team also recognised that some of the functionalities were currently not

fit for purpose. Moreover, they could not draw on others experiences as

some of the functionalities were not previously adapted for use in the UK.

'I don't think there has been a better way to do it because we have no precedent to follow. I think certainly for things like IVs, nobody else in the whole of the UK had looked at that so it was very difficult to do anything other than practicality'

Interview 5, senior nurse

However, the ePMA group obtained information about potential deliverable

functionalities due to progressing work elsewhere.

'We know that in our IV and hydration infusions there isn't a good functionality so we are treating it as a medicine to deliver it but we know that functionality is coming because Australia work in the same way, they prescribe IV fluids bag by bag and they sequence them so those two things will come not at our current code level but the next ones. I also feel quite confident, because of the structure of the meetings now, I feel I am receiving more information now that we will go to the next code level or even higher quite quickly. So, I think those things will be delivered'

Interview 2, senior pharmacist

b) Design principles for the build:

1. Standardisation of prescribing:

An essential design principle was to build a safe and user friendly system.

'I think the generic approach has been to, like I said earlier, is that it's to make it as easy for the users as possible and keep the system as safe as possible. So I think safety is the thing you go to first and then if it's safe you then go to whatever is easiest for the end-users. I think they are probably the main two principles'

Interview 4, senior pharmacist

Therefore, the build had to incorporate order sentences, and care sets for

most of the prescribing to reduce key strokes and standardize prescribing.

'we have a local approach that says the basic level screens where you do lot of order entry was too many key strokes, too complicated but it had the ability to build lots of order sentences in fixed care sets and we hope that having built a lot of those it will really ease the standardisation [.....] reduced key strokes and making it easier to prescribe the correct thing, huge drivers, huge, huge drivers. That would be, I think, our main design features; making it easier to do the right thing'

Interview 1, senior pharmacist

Efficiency obtained through standardisation was perceived as an opportunity

to free staff for clinical roles

'we had developed a view there that really safety and quality comes a lot from standardisation and if we can get standardisation, I think as I said earlier, you get the benefit then from reviewing those patients who are not standard and adding value and bringing your workforce on, and against a concern'

Interview 1, senior pharmacist

2. Minimising unnecessary customisation

Another design decision was to minimise redesigning of drug catalogues and

system customisation to reduce amount of back-office work required later.

'It has also been a design principle that we didn't design anything in a drug catalogue that meant it was hard work to keep updating it as we didn't think there would be a lot of ongoing resources'

Interview 1, senior pharmacist

5.6 Discussion:

5.6.1 Key findings:

The findings of the present study suggest that implementation of the

integrated ePMA system in the Trust was driven by various factors.

Interviewees perceived that the Trust had many failing internal systems and

so there was an opportunity to review, update and unify systems. Moreover, the potential benefits of EP over paper-based prescribing and the integration of all clinical processes across all Trust hospitals were recognised. Financial incentives of the NPfIT were one of the specific motives to implement the integrated system, rather than taking any other approach, within the Trust.

The ePMA stakeholders cited several features to be sought when selecting an ePMA system. The stakeholders group were not involved directly in selecting the system per se. Despite the rigidity of the system implemented, stakeholders thought it had potential to deliver many of the desired features of an ePMA system.

Many factors influenced the ePMA project, including the trust past experiences. Interviewees highlighted perceived challenges related to the project management such as resources, staff retention, staff attributes, staff engagement and documentation challenges. They also acknowledged issues related to the shifting timescales of the project as well as the inadequate communication between modules groups. Therefore, the adopters 'the ePMA group' had several concerns throughout the implementation project.

The above mentioned challenges are well documented in organisational research. Challenges related to a variety of areas in HIT implementation projects were cited in the literature such as knowledge and management (Lorenzi and Riley, 2003), people and organizations (Lorenzi et al, 1997), and social communication patterns (Davidson, 2000).

The findings of the present study revealed not only the complexity of the project, but also the risk of the organisational memory loss. Staff changes,

inadequate documentation and the lack of project management skills all contributed to the perceived risk of memory loss. Organisation memory loss, also known as organisational or corporate amnesia, is well documented in the literature (Kransdorff, 1998; Bate et al, 2008). Arguably, failure of organisations to document knowledge and experience may hinder organisational learning which is important for successful HIT implementations.

The present study revealed that the ePMA group had identified a general working strategy and system design principles to facilitate the building of a safe system and overcome some of the perceived challenges.

5.6.2 Implications for clinical practice:

In-depth case studies are context dependent. Therefore findings may not be generalizable. However, learning lessons may be transferable to similar settings and contexts. Identifying potential challenges that staff might face when implementing an ePMA system of a similar scale may help potential adopters prepare for such change. Moreover, working strategies and design principles employed in the present study may be relevant to other potential adopters. The study highlighted some of the issues which might face NHS hospitals implementing ePA integrated into EHR systems. Lack of NHS staff expertise in project management and documentation is one aspect that should be addressed. Appropriate documentation and staff retention may assist retaining the organisational memory and facilitate learning.

5.6.3 Strengths and limitations of the work:

Obtaining data from multiple sources increases the strength and validity of case studies finings. A limitation of the present study was the small number and the relatively narrow range of interviewees. Another disadvantage was potential observer bias due to the nature of qualitative research. However, transparency in methods used as well as using a pre-defined conceptual framework to guide conducting interviews, as well as to analysing and to data interpretation minimised the risk of bias.

5.7 Conclusion:

Implanting an 'off-the-shelf' ePMA system as part of a whole hospital integrated system was perceived by stakeholders to be complex and challenging. There were several problems that delayed system implementations in the trust. There were also perceived challenges due to staff changes, lack of expertise in project management, documentation challenges as well as complexity of the foreign technology itself. Despite all the above challenges, the ePMA team identified strategies to facilitate system design and build. The findings of the present work may be transferrable to similar contexts.

Chapter 6: Economic impact of electronic prescribing use in secondary healthcare setting: a systematic review of the current literature

6.1 Introduction:

The studies presented in chapters two and three showed that EP could be used in several ways in a hospital. The findings of chapters four and five highlighted that adoption plans for a whole hospital EP system may have to be changed in many ways. There are many decisions to be made while an EP system is being designed and customised for a specific site. Therefore, government policy makers and decision makers in hospitals will need to establish if EP systems use in hospitals is cost effective. This chapter presents an overview of the literature assessing the economic impact of EP utilisation in secondary care. First, the chapter starts with an introduction about health economics and a summary of existing literature. This is then followed by a detailed description of the methods used in this review, the main findings and a discussion of the main results. Previous reviews conducted in this area have mainly explored the economic effects of a range of technological interventions used in various healthcare settings. In contrast, the present review takes a different approach and focuses specifically on EP use in the hospital setting. The chapter ends with a summary highlighting the main conclusions of the review and their implications on clinical practice.

6.1.1 Economic evaluation of technology in healthcare

Maintaining high quality standards and delivering seamless patient care has been one the main targets of healthcare systems. There is a soaring demand for healthcare worldwide. This is due to ageing populations, increasing prevalence of long term conditions, as well as new treatments launched in the market (Car et al, 2008). The net result is inexorable growth in healthcare expenditure. The challenge that most healthcare organisations face under the current financial climate is reducing costs and increasing productivity while improving quality standards for healthcare. As a result of scarcity and constrained resources, economics have been increasingly used to rationalise choices in healthcare. The term 'economic evaluation' was defined by Drummond and colleagues as:

'a comparative analysis of alternative courses of action in terms of both their costs and consequences' which means that decisions are not based solely on costs but also outcomes have to be considered'

(Drummond et al, 2005)

The emergent role of health economics has become an established concept yet there remains a lot of debate about the best evaluation techniques to use (Shiell et al, 2002). Several evaluation approaches have been used for the assessment of technological interventions in healthcare (Tarride et al, 2009). These evaluations could be based on primary data alongside clinical trials or be based on modelling techniques. The main methods used are cost effectiveness analysis (CEA), cost minimisation analysis (CMA), cost utility analysis (CUA) and cost benefit analysis (CBA). CEA is a form of economic evaluation used when outcomes are one dimensional and measured in natural units such as mortality while costs are measured in monetary values. Conversely, CBA assesses all effects of interventions, including outcomes, in monetary values. CUA broadly follows the same principles of cost effectiveness analysis, however outcomes are measured by the quality adjusted life year (QALY). CMA allows the comparison of two equally effective interventions in terms of their costs. The latter approach is now considered as cost analysis instead of full economic evaluation (Drummond et al, 2005). Often, data used in economic evaluations are derived from various sources and may well include experts' opinions and estimates if empirical evidence is insufficient. This has generated doubts about the findings of economic evaluations (Tarride et al, 2009). Moreover, in many cases health economists tend to perform economic evaluations using analytic decision modelling techniques which are based on mathematical representation of interventions' costs and outcomes. These are often carried out when evidence is lacking or when it's not possible to conduct trials or when information beyond a follow up period of a study is required (Buxton et al, 1997).

Technology has started percolating into healthcare, be it in administrative matters or clinical matters. This includes EHR, EP systems, CDSS, pathology and radiology diagnostic systems, automated dispensing machines, electronic materials management, bar coding, etc. These HIT may potentially facilitate communication and interoperability between and within different healthcare organisations and are generally viewed as a promising tool to enhance efficiency and quality in healthcare systems (Hillestad et al, 2005). The use of EP systems is advocated in the literature as one of the modes to reduce medication errors (Bates et al, 1998; Leape et al, 2000;

Mekhjian et al, 2002), improve patient safety (Kaushal et al, 2003) and increase efficiency (Shekelle and Goldzweig, 2009). However, similar to most technologies, they are associated with substantial acquisition costs, capital investments, on-going support costs, and can require enormous organisational change (Hillestad et al, 2005). Estimates of up to \$8 million for an implementation of a CPOE in a 500-bed US hospital were reported in the literature (Kuperman and Gibson, 2003). Therefore, many healthcare institutions are seeking evidence from previously implemented systems about the economic impact of technology adoption in order to better inform decisions about the optimal choice and strategy for implementation.

There are limited data in the literature about the cost effectiveness of adopting technology in healthcare settings (Shekelle and Goldzweig, 2009). This might be at least partly due to the complexity of estimating direct and intangible costs and identifying contributing factors associated with this technology. Moreover, the variations in study designs applied and systems used in the literature make extrapolating data extremely difficult. Corley (2003) found EP software use to be cost effective in the general practice setting for all size practices with a more rapid return in investment in larger practices in the US. However, the EP software had very basic functionalities and it was used to generate prescriptions transmitted to pharmacy via fax. A more recent review which aimed to assess the evidence on the impact of HIT on all phases of the medication management process reached no definitive conclusion as to whether the additional costs and benefits represent value for money (AHRQ, 2011). This was essentially due to the uncertainty of costs and outcome data coupled with limited study designs available in the

Page 213 of 305

literature. Another review found that the financial effects of computerised provider order entry are context dependent (Shekelle and Goldzweig, 2009). The authors of the most up to date published review evaluating HIT economic impact were not able to conduct a systematic review due to the heterogeneity of studies in numerous aspects (O'Reilly et al, 2012). The thirty one studies identified varied in technology evaluated, setting, and the economic evaluation technique used. Only five of the thirty studies were found to have conducted a full economic review. The review found that few studies showed that HIT may offer an advantage although it was costly. However, it was difficult to prove if it was good value for money in the light of all the limitations of the review's findings. Moreover, studies evaluating CPOE and/or CDSS showed mixed results. The authors of a recent scoping review of health information systems' economic evaluations found a wide range of economic evaluation papers that were based on different assumptions, methods, and metrics (Bassi and Lau, 2013). Bassi and Lau found that 69.7% (n=23 of 33) or of the papers reported positive findings demonstrating value. However, the authors concluded that the findings could not be generalised as these economic evaluations were for specific HIT in a specific setting. Furthermore, similar to O'Reilly et al. (2012), studies evaluating CPOE and/or CDSS identified by Bassi and Lau showed mixed outcomes (Bassi and Lau, 2013).

6.1.2 Promoting technology in healthcare as a government policy

It is increasingly becoming government policy to promote the use of technology in healthcare institutions. In May 2013, the UK minister of health announced a £250 million "safer hospitals, safer wards" technology fund for

NHS trusts to bid for, aiming for technology delivery in 2015 (NHS England, 2013). This fund was doubled in September 2013 to aid reaching the goal of facilitating access of information to healthcare professionals in order to provide seamless care for patients. These steps in the UK mirror the US government legislation initiatives to spread meaningful use of healthcare information technology through the Medicare and Medicaid incentive program (Centre for Medicare and Medicaid Services, 2013). An estimate was made that these technologies would lower medical costs by \$100 billion annually within the US and increase administrative efficiency.

It was projected in a recent report commissioned by the UK DoH that driving the roll out and use of EP in secondary care in the UK will yield an estimated cost saving of £270 million per annum as a result of reduced rates of avoidable ADRs (PriceWaterhouseCooper, 2013). This was calculated based on reducing 60% of preventable ADRs when 50% of trusts successfully implement a system that has a capital cost of £63m at year one followed by a running cost of £15m every year. These projections were based on data from case studies in the UK and the US. Therefore, there is some doubt about their applicability to the UK context. Furthermore, it was assumed that these systems are used effectively by staff members, operate in line with design, and link to shared EHRs.

In view of the above, implementation of EP in UK secondary care is an important item of government policy. There are some reviews which have attempted to assess the financial rewards of implementing technology in healthcare settings. However, these reviews found that evidence is poor and studies seem to vary considerably in many aspects including design, setting, the technology used, and the technique of evaluation performed. In an attempt to control for such diversity in existing evidence, this review now aims to target literature relevant to the current UK context. The purpose of our review is to narrow the selection of papers to explore primary literature in this area in the context of secondary care setting and only targets EP 'or CPOE in US studies' adoption.

6.2 Aims and objectives:

This review aims to examine the evidence on the economic impact of EP implementation in the secondary care setting. Therefore, it seems more appropriate to include economic evaluations of EP systems or similar in hospitals setting for two reasons. The first is to try and avoid the problem of variability of papers described in previous reviews. The second is to guarantee tailoring this review to the current perspective of UK government technology policy. The purpose is then to compare the findings of this review to previous reviews discussed above.

6.3 Methods

The objective of this work was to explore economic evaluations of EP implemented in secondary care setting. Given the scarcity of publications in this area and the narrow inclusion criteria selected, it was decided to include all relevant papers published and not focus on recent literature. A review protocol was drafted based on the Cochrane collaboration protocol guide for the purpose of this work. Several data collection sheets were developed to ensure quality and transparency in conducting and presentation of
systematic reviews and meta-analysis. The PRISMA checklist was used in the assessment and reporting of this review (Moher et al, 2009).

6.3.1 Criteria for selecting studies for this review:

The review had a set of inclusion and exclusion criteria in various parameters including: study design, type of economic evaluation, setting, participants, intervention evaluated, outcome measures and language. Below is a detailed description of the studies selection criteria for this review.

6.3.1.1 Study aims and design

The studies had to be either RCTs, controlled clinical trials (CCTs), before/after studies (BAs) or interrupted time series (ITS) studies, cohort studies or economic evaluation studies with or without modelling techniques to be considered for inclusion.

6.3.1.2 Type of economic evaluation:

Full and partial economic evaluations were considered for inclusion. Full economic evaluation was defined as the comparative analysis of alternative courses of action in terms of both costs and consequences (Drummond 2005). Full economic evaluations thus included CEA, CUA and CBA. Studies that reported costs (resource use) and/or monetary consequences but did not make explicit comparisons between alternative interventions in terms of both costs and consequences were considered partial economic evaluations (The Cochrane Collaboration, 2011). Studies which assessed association of the intervention to costs and not causality were excluded.

6.3.1.3 Setting and participants

Economic evaluations of studies of EP use in secondary and tertiary care settings were considered for inclusion. This included general hospitals, speciality hospitals, acute and foundation trusts. If any study was conducted in multiple sites of variable settings, data were included if the information about secondary and/or tertiary care settings could be extracted separately. Studies conducted in primary care, ambulatory care and long term care facilities such as nursing or residential homes were out of the scope and excluded. In cases with any ambiguity in the description of the institution, the authors were contacted for clarification. Any patient group was considered for inclusion. For example, general hospital populations or specific populations such as paediatrics were included.

6.3.1.4 Types of intervention.

EP or CPOE systems which offer prescribing a wide range of drugs for inpatients and/or discharge purposes were the target intervention for this review. Studies were then further classified according to the intervention used and the presence of any other technologies coupled with EP. Studies evaluating prescribing packages for a specific class of drugs, such as chemotherapy or anticoagulants, were excluded.

6.3.1.5 Types of outcome measure

Studies reporting any economic outcome measure related to the intervention evaluated were included. Non-monetary outcomes were excluded from the study.

6.3.1.6 Language

Studies were included if the full text was published in English and could be extracted. Economic evaluations published in other languages were excluded.

6.3.2 Search methods

6.3.2.1 Databases:

A structured electronic search strategy was developed and carried out in the following databases: The Cochrane Library, MEDLINE, EMBASE, PsycINFO, International Pharmaceutical Abstracts, the NHS Economic Evaluation Database, the European Network of Health Economic Evaluation Database and the Web of Science for conference proceedings up to October 2013. Facets relating to (1) EP/CPOE and (2) economic evaluation were searched for. Details of the MEDLINE database search strategy are presented in appendix P. References of relevant previous reviews were also screened to detect any papers that could be included in this review. (AHRQ, 2011; O'Reilly, 2012; Bassi and Lau, 2013).

The electronic search was then updated in December 2014. All the electronic databases were explored excluding the European Network of Health Economic Evaluation Database as it was no longer accessible.

6.2.3.2 Hand search:

All issues of five key journals published between 2006 and 2013 were screened manually to identify any potential articles that could be included in this review.

The following journals were searched by hand for relevant articles:

- International Journal of Technology Assessment in HealthCare
- International Journal of Healthcare Technology and Management
- Journal of the American Medical Informatics Association
- Journal of Evaluation in Clinical Practice
- Journal of Health Economics

6.3.3 Data extraction:

The literature search was conducted October/November 2013. A review protocol and study assessment sheet, and data extraction template were created and used to standardise the selection method and guide the researcher through the process. The abstracts and titles of the articles were screened and assessed for relevance by a researcher (ZA). Whenever there was any doubt, the full text of the original article was obtained in order to decide if it met the selection criteria. A quality check for all the screening process was conducted in November 2013. A random sample (10%) of abstract and titles as well as the full article retrieved were reviewed by a second researcher (SG). Data extraction was conducted independently by two researchers (ZA and YJ). Whenever there was disagreement, this was resolved by consensus and if necessary a review by a third researcher (BDF). Assessment of quality of the articles selected was conducted using a checklist developed by Drummond and colleagues (Drummond and Jefferson, 1996).

6.3.4 Analysis

Results were analysed according to quality, design and heterogeneity of the papers identified. The studies were classified according to design, intervention used, comparator, population and the outcome measures assessed.

6.4 Results:

6.4.1 Search results:

The electronic search resulted in 1615 unique articles after removing 226 duplicates (Figure 6 -1). These were obtained from five databases. Three databases did not yield any relevant papers (PSYCHINFO, The Cochrane Library, and the European Network of Health Economic Evaluation database). Screening relevant previous reviews and the hand search did not result in any additional unique papers. The full texts of 35 articles were obtained and screened for eligibility. Of these 28 papers did not meet the inclusion criteria. Reasons of exclusion at this stage was the lack of primary data (19), inability to obtain full text (3), setting (1), language (1), and the lack of relevant outcome measure (3). Agreement of abstract and titles screening as well as full text screening between the two researchers was 91% (n= 116 of 1160) and 100% (n= 3 of 30) respectively. Only seven articles met the inclusion/exclusion criteria (Vermeulen et al, 2014; Zlabek et al, 2011; Stone et al, 2009; Karnon et al, 2008; Wu et al, 2007; Kaushal et al, 2006; Mekhjian et al, 2002). On the whole, studies varied significantly in all aspects evaluated therefore conducting a meta-analysis was not possible. The next section shows the characteristics of the studies included in details.

Figure 6 - 1: Prisma flow chart showing the screening and selection process



*Sample check was conducted in November 2013 following the first search. At that time the total numbers of unique papers identified was 1160.

6.4.2 Characteristics of studies included in the review:

All the papers were published between 2002 and 2014. This was not unexpected as the topic of evaluating economics of HIT is relatively recent (O'Rielly et al, 2012). A review by O'Reilly et al, (2012) has reported that 74% of the publications they have identified were published after 2001. A detailed description of the studies included in this review is displayed in tables 6 - 1 and 6 - 2.

6.4.2.1 Study design:

The studies also were diverse in design (Tables 6- 1, 6 - 2). Three were BAs (Zlabek et al, 2011; Stone et al, 2009; Mekhjian et al, 2002). Vermeulen et al (2014) conducted an economic evaluation alongside an ITS study. An incremental cost analysis was conducted by Wu et al. (2007). Kaushal et al, 2006 estimated costs and benefits of a hospital CPOE system over ten years while Karnon et al. (2008) developed a model structure to describe the incidence of medication errors and potential costs and benefits of three key interventions.

6.4.2.2 Type of economic evaluation:

The type of economic evaluation applied varied among the eight studies. Only three studies were found to be full economic evaluations. Wu et al. (2007) and Vermeulen et al. (2014) used CEA while Karnon et al. (2008) used CUA. The remaining publications were classified as partial economic evaluations.

6.4.2.3 Studies setting and populations:

Apart from three studies, one conducted in the Netherlands (Vermeulen et al, 2014), on in the UK (Karnon et al, 2008) and the other in Canada (Wu et al, 2007), the remaining were all conducted in the USA. Three studies (Zlabek et al, 2011; Stone et al, 2009; Kaushal et al, 2006) were based in a single tertiary care hospital. Of these, only one paper (Zlabek et al, 2011) described in detail the level of care provided and number of beds in the hospital. One the other hand, three studies researched multi-site healthcare institutions. Wu et al. (2007) and Mekhjian et al. (2002) evaluated interventions conducted in a three site healthcare institutions while Vermeulen et al. (2014) evaluated an intervention in two healthcare institutions. The remaining study had no actual setting and all cost estimates were based on a theoretical model of a 400 bed British acute hospital (Karnon et al, 2008).

6.4.2.4 Interventions assessed and comparators:

Interventions and comparators varied between included economic evaluations (tables 6 -1, 6 - 2). Interventions assessed included CPOE systems, CPOE combined with CDSS, CPOE combined with MAR, and CPOE combined with EHR. Only one article reported the vendor, type and version of CPOE evaluated (Zlabek et al, 2011). The rest were either partially described or no information were provided about the systems. Comparators of interventions were similarly variable. CBAs assessed the cost impact before and after interventions implementation without specifying prescribing method used before the intervention. One study compared intervention to paper-based ordering (Wu et al, 2007). Karnon et al. (2008) assessed CPOE against two other interventions (ward pharmacist and bar coding).

Page 224 of 305

6.4.2.5 Outcomes measures:

Generally, the studies varied in the outcomes measure assessed. Four economic evaluations reported economic outcomes related to medications (Vermeulen et al, 2014; Karnon et al, 2008; Wu et al, 2007; Kaushal et al, 2006) while three economic evaluations reported outcomes related to medications as well as other aspects of the systems evaluated (Zlabek et al, 2011; Stone et al, 2009; Mekhjian et al, 2002). The next section demonstrates in details the economic findings of the studies.

6.4.3 Economic impact assessment

On the whole, the mode by which the financial impact of the technology was assessed varied considerably between the studies published. This section provides an overview of the economic findings of the included studies. Findings are reported based on the economic outcome measure.

6.4.3.1 Studies reporting economic outcomes directly related to medication

There were a total of four studies in this category. Overall, half of the studies reported financial benefits associated with medication aspects of the implemented systems (Kaushal et al, 2006; Karnon et al, 2008). Kaushal et al. (2006) estimated upfront costs of development and implementation of a fully operational CPOE to be \$11.8 million. Over ten years, the system saved a total of \$28.5 million. This was the sum of cumulative net savings of \$16.7 million and net operating budget savings of \$9.5 million given the institutional 80% prospective reimbursement rate. The authors obtained data about the costs of the CPOE system from institutional experts. Benefits were

determined from published studies of their CPOE system, interviews with hospital experts, and relevant internal documents.

According to Karnon et al. (2008), CPOE was associated with no probability of producing positive net benefits when only health service costs were considered in the model. Nevertheless, a net benefit with a mean estimate of around £31.5 million for CPOE over five-years was obtained when monetary value of lost health (health effects of pADEs) was included in the analysis.

It was reported in another study, that the incremental costs for the intervention compared with a conventional approach were found to be a total of \$ 3,322,000 over the ten year horizon (Wu et al, 2007). Estimates of the effect of the system were obtained from the literature while cost data were obtained from a healthcare institution in Toronto, Canada. The paper reported an incremental cost-effectiveness of \$12,700 per ADE prevented after system implementation. The authors found the cost-effectiveness to be sensitive to the ADE rate, the effectiveness of the new system, the cost of the system, and costs due to possible increase in doctor's workload. A more recent study compared CPOE/CDSS to the traditional paper-based medication ordering (Vermeulen et al, 2014). Authors found that an additional 3.54 euro and 322.70 euro has to be invested compared to the paper-based system to prevent one extra medication error and pADE respectively.

6.4.3.2 Studies reporting economic outcomes related to medications and other aspects of the system

Overall, two of the three studies reported some financial benefits of systems implementation (Zlabek et al, 2011; Stone et al, 2009) while one reported no effect when all services evaluated were combined (Mekhjian et al, 2002). However, the full financial effect of systems use was not evaluated in these studies. Zlabek et al. (2011) reported that monthly transcription costs declined from \$74,596 to \$18,938 (74.6%) and a total \$30,531 paper savings was achieved. In addition, it was reported that laboratory tests orders per week decreased by 18%, and radiology imaging declined by 6.3% however, these measures were unfortunately not quantified. Despite including this as a study measure, the cost saving of this decline was unfortunately not documented in the paper. The review also examined some quality markers such as length of stay (LOS), readmission within 30 days, case mix index, risk adjusted mortality as well as medication errors as safety measures with no assessment of the financial impact of these measures.

Stone et al. (2009) reported a total capital cost for the implementation project of \$2.9 million, with additional operating cost of \$2.3 million. The research team reported a yearly financial benefit of \$445,500 as unit secretaries were no longer required to clarify orders and transcribe them. Despite the documentation of the CPOE costs, the full financial effect of its implementation has not been evaluated.

Mekhjian et al. (2002) concluded that severity adjusted total cost per admission did not change significantly in either state hospital (pre-POE, \$5,697; post- POE, \$5,661; p=0.687) or in the Cancer hospital (pre-POE, \$6,427; post-POE, \$6,518; p=0.502) when all services were combined.

However, there were variations between different clinical areas.

Year Author	Type of economic	Study aim	Study design & setting	Intervention & comparator	Time horizon	Population	Effect measures	Currency (year) &	Main economic findings
country	evaluation			(system name and version)				cost elements	°,
2014 Vermeulen et al Netherlands	Full economic evaluation Cost- effectivene ss analysis	To study the balance between the effects and costs of CPOE/CDS S compared to the traditional paper-based medication ordering	An economic evaluation performed alongside a clinical study (interrupted time series design) A general teaching hospital (500 beds) and A University Medical Centre (1500 beds)	CPOE with basic CDSS vs. paper based system. A partly home- grown system (Theriak®, Theriak evf, Tilburg). Commercial system (Medicator®, iSOET Leiden)	2005 - 2008	Patients admitted to the general internal or the geriatric ward of the general teaching hospital or those admitted to the general internal medicine ward, or the gastroenterology ward during the study period	Medication errors and pADE.	Euros (price level 2009)	An additional 3.54 euro has to be invested compared to the paper based system to prevent one extra medication error. An additional 322.70 euro has to be invested compared to the paper based system to prevent one extra pADE.
2008 Karnon et al UK	Full economic evaluation (Cost utility analysis)	To estimate the potential costs and benefits of three key interventions that aim to reduce the impact of medication errors	Modelling structure developed to describe the incidence and impacts of medication errors on hospitals' costs. This model included a decision tree to describe a series of error points and subsequent error detection points in	CPOE/CDSS vs. ward pharmacists vs. bar coding theoretical system	5 year time horizon	The model was populated with quantitative estimates of the incidence and impacts of MEs. The potential effectiveness of interventions was described by estimating its	Quality of life utility decrements associated with experiencing a pADE	UK. sterling (2006) Interventio ns, efficiency savings, treatment of, and the bealth	Health service costs only: CPOE was associated with no probability of producing positive net benefits. Monetary value of lost health included: Estimated monetary valuations of the bealth effects of
			No actual setting (A theoretical model of a 400-bed acute hospital)			impact on error incidence and detection rates.		effects of pADEs.	pADEs A net benefit with a mean estimate of around £31.5 million for CPOE over five-years.

Table 6 - 1: Summary of the articles reporting economic outcomes directly related to medication

LOS: length of stay; CPOE: computerized physician order entry; pADEs: preventable adverse drug reactions; e-MOE: electronic medication order entry system; MAR: medication administration record; USD: US dollars; CDSS: clinical decision support system.

Year Author country	Type of economic evaluation	Study aim	Study design & setting	Intervention & comparator (system name and version)	Time horizon	Population	Effect measures	Currency (year) & cost elements	Main economic findings
2007 Wu et al Canada	Full economic evaluation (Cost effectiveness analysis)	To determine the potential incremental cost- effectiveness of an e- MOE/MAR system	An incremental cost-effectiveness analysis was performed comparing an MOE/MAR to the standard system used University Health Network is an association of three University of Toronto teaching hospitals (700 beds in total)	MOE/MAR with CDSS vs. standard paper ordering (misys CPR® , Misys Healthcare Systems) version not specified	a 10-year time horizon with 5% discount rate)		Reduction of pADEs and associated mortality (from literature)	USD (2004) Implementatio n costs (software, project management, clinical team involvement and training); operating costs (support for new interface, training))	The incremental costs for the MOE compared with a conventional approach were \$3 322 000 over the 10-year. The incremental cost-effectiveness of the new system was \$12 700 (USD) per ADE prevented. The cost-effectiveness was found to be sensitive to the ADE rate, the effectiveness of the new system, the cost of the system, and costs due to possible increase in doctor workload.
2006 Kaushal et al USA	Partial economic evaluation	To assess the costs and financial benefits of the CPOE system over ten years	Cost and benefit estimates of a hospital CPOE system 720 bed, adult tertiary care academic hospital. (Brigham and Women's Hospital)	CPOE with CDSS (home grown system) version not specified	10 years (with 7% discounti ng)	patients admitted between 1993 and 2002	Reductions in ADEs ,LOS, proportion of appropriate prescriptions laboratory and radiology tests (some measures from the literature)	USD 2002 Capital and operational costs, drug costs, hospital costs	Between 1993 and 2002, the Birmingham Women Hospital spent \$11.8 million to develop, implement, and operate CPOE. Over ten years, the system saved BWH \$28.5 million (17.1 million were directly related to medications prescribing) for cumulative net savings of \$16.7 million and net operating budget savings of \$9.5 million given the institutional 80% prospective reimbursement rate.

Table 6 - 1 continued: Summary of the articles reporting economic outcomes directly related to medication

LOS: length of stay; CPOE: computerized physician order entry; pADEs: preventable adverse drug reactions; e-MOE: electronic medication order entry system; MAR: medication administration record; USD: US dollars; CDSS: clinical decision support system.

Year Author	Type of economic	Study aim & objectives	Study design & setting	Technology intervention &	Time horizon	Population	Effect measure	Currency (year) & cost	Main economic findings
country	evaluation	—		comparator				elements	
2011	Cost	To study the	Retrospective				Quality markers:	USD	Monthly transcription
Zlahali	analysis	effects of an	longitudinal	(Epic, Verona,			LOS, readmission	(2008/2009)	COStS declined from
Zlabek	(partial	Inpatient ERR	analysis study				within 30 days,		\$74,596 t0 \$18,938
et al	economic	System with	Defore/after				case mix index,		(74.6%)
110 1	evaluation)		(ERR/CPOE)	+ CPUE			mortality		Total paper covings of
034		of care and cafety	Implantation	(IIUL described)			monality.		¢20 521
		of cale and salety.	Community	uescribeu)			Cost of care		\$30,531
			based tertiary				measures: Lab		
			referral centre				tests and		
			and a teaching				radiology		
			hospital				examinations		
			325 beds & a				completed,		
			level II trauma				transcription		
			centre				costs, paper		
			(Gunderson				consumption		
			Lutheran				Safety		
			Medical Centre).				measures:		
			,				Medication errors.		
2009	Cost	Review of	Retrospective	CPOE		Number of	Patient safety,	USD	Yearly financial benefit of
	analysis	the impact of	and prospective	(not described)		surgical	medication errors,	(2007/2008)	\$445,500 (unit secretary
Stone	(partial	implementation of	analyses of			procedures	order		was no longer required to
et al	economic	a CPOE system	patient-safety			pre and post:	implementation	Personnel	clarify orders and
	evaluation)	within an	measures 6			6,815	time	and capital	transcribe the written
USA		academic surgical	months pre- and			procedures		costs of	orders).
		practice	6 months post-			in the pre		implementati	
			CPOE.			period and		on	I otal capital cost for the
						5,963 in the			implementation project
			Multispecialty			first post 6			was \$2.9 million, with
			nospital			month and			additional operating cost
						6,106 in the			ot \$2.3 million.
			surgical practice			second b			Full financial effect has
						months post			not been Evaluated.
			nospital)			implementati			
						on			

Table 6 -2: Summary of articles reporting economic outcomes related to medications and other aspects of systems

LOS: length of stay; CPOE: computerized physician order entry; pADEs: preventable adverse drug reactions; e-MOE: electronic medication order entry system; MAR: medication administration record; USD: US dollars; CDSS: clinical decision support system.

Year Author country	Type of economic evaluation	Study aim & objectives	Study design & setting	Technology intervention & comparator	Time horizon	Population	Effect measure	Currency (year) & cost elements	Main economic findings
2002 Mekhjian et al USA	Cost analysis (partial economic evaluation)	To evaluate the benefits of a CPOE and eMAR on the delivery of healthcare	Before-and- after CPOE and within post-CPOE for a period of 10-12 months across all services in the respective hospitals Cohort of inpatient nursing units in an academic health system (3 sites),	Pre-CPOE and post- CPOE and, within post-CPOE (a comparison of CPOE and the combination of CPOE plus eMAR)		Inpatient nursing units	LOS, medication, radiology, and laboratory test turnaround times, medication transcription errors	USD (2002) Total costs per patient	Overall: When all the services were combined, severity adjusted total cost per admission did not change significantly in either state hospital (pre-POE, $\$5,697$; post-POE, $\$5,661$; <i>p</i> =0.687) or in the Cancer hospital (pre-POE, $\$6,427$; post-POE, $\$6,518$; <i>p</i> =0.502)) State hospital: Total costs for the heart transplant service (pre-POE, $\$5,264$; post-POE, $\$4,871$; <i>p</i> =0.013) and organ transplant service (pre-POE, $\$5,264$; post-POE, $\$4,871$; <i>p</i> =0.043) showed a statistically significant decrease, whereas costs for general surgery (pre-POE, $\$4,995$; post-POE, $\$5,567$; <i>p</i> =0.008) showed a statistically significant decrease. There were no statistically significant changes in other services. Cancer hospital: services such as surgical oncology (pre-POE, $\$6,087$; post-POE, $\$5,631$; <i>p</i> = 0.008) and neurology/neurosurgery (pre-POE, $\$5,600$; post-POE, $\$5,125$; <i>p</i> =0.045) showed statistically significant reductions in total costs, whereas the gynaecology/oncology service (pre-POE, $\$5,046$; post-POE, $\$5,821$; <i>p</i> <0.001) showed a statistically significant increase in total costs and thoracic surgery (pre=POE, $\$5,181$; post=POE, $\$5,946$; <i>p</i> = 0.055) showed a non-significant increase. There were no significant increase.

Table 6 - 2 continued: Summary of articles reporting economic outcomes related to medications and other aspects of systems

LOS: length of stay; CPOE: computerized physician order entry; pADEs: preventable adverse drug reactions; e-MOE: electronic medication order entry system; MAR: medication administration record; USD: US dollars; CDSS: clinical decision support system.

6.4.4 Quality assessment and limitations of the studies:

Quality assessment was carried out against a checklist developed by Durmmond and colleagues (Drummond and Jefferson, 1996). The checklist included 36 criteria related to study design, data collection as well as analysis and interpretation of the results. The quality assessment of the studies reporting economic outcomes directly related to medication is shown in table 6 - 3. All full economic evaluations identified in the review fell into this category. Generally, the studies presented in table 6 - 3 were found to be of better quality than the rest of the economic evaluations identified (Vermeulen et al, 2014; Karnon et al, 2008; Wu et al, 2007; Kaushal et al, 2006).

Overall, studies found varied significantly in quality and transparency of reporting their methods and results. Although the research questions were clearly stated in these studies, the economic evaluation selection in relation to the research question was rarely justified. Details about data collection and analysis were lacking. The details of price adjustment, discounting, time horizon and currency conversion were not reported in some of the studies identified. Many of the data fed into these evaluations were made based on unjustified assumptions and/or information from databases based on voluntary reporting system which might affect the accuracy of the evaluations' results. Generalizability issues were not addressed. For example, Karnon et al. (2008), had developed a decision model of a UK based hospital however, used data based from the US that is not appropriate for the UK context. In some instances, costs and benefits were assumed to be equally affected by inflation although they were assessed in different points in the model (Kaushal et al, 2006).

Criteria	Vermeulen et al	Karnon et al	Wu et al	Kaushal et al
Study design				
(I) The research question is stated	+	+	+	+
(2) The economic importance of the research question is stated	+	+	+	+
(3) The viewpoint(s) of the analysis are clearly stated and justified	+	+	+	+
(4) The rationale for choosing the alternative programmes or interventions				
compared is stated	+	+	+	+
(5) The alternatives being compared are clearly described	+	+	+	+
(6) The form of economic evaluation used is stated	+	+	+	+
(7) The choice of form of economic evaluation is justified in relation to the				
questions addressed	-	-	-	-
Data collection				
(8) The source(s) of effectiveness estimates used are stated	+	+	+	+
(9) Details of the design and results of effectiveness study are given (if				
based on a single study)	+	+	+	+
(10) Details of the method of synthesis or meta-analysis of estimates are				
given (if based on an overview of a number of effectiveness studies)	NA	NA	NA	NA
(II) The primary outcome measure(s) for the economic evaluation are				
clearly stated	+	+	+	+
(12) Methods to value health states and other benefits are stated	+	+	+	+
(13) Details of the subjects from whom valuations were obtained are given	NA	+/-	NA	+/-
(14) Productivity changes (if included) are reported separately	NA	NA	NA	NA
(15) The relevance of productivity changes to the study question is				
discussed	NA	NA	NA	NA

 Table 6 - 3: The quality assessment of the studies reporting economic outcomes directly related to medication

(6) Quantities of resources are reported separately from their unit costs	+	+	+	+
(17) Methods for the estimation of quantities and unit costs are described	+	+	+	+
(18) Currency and price data are recorded	+	+	+	+
(19) Details of currency of price adjustments for inflation or currency				
conversion are given	+	+	+	+
(20) Details of any model used are given	+	+	NA	-
(21) The choice of model used and the key parameters on which it is based				
are justified	+	+	NA	-
Analysis and interpretation of results				
Analysis and interpretation of results				
(22) Time horizon of costs and benefits is stated	+	+	+	+
(23) The discount rate(s) is stated	-	-	+	+
(24) The choice of rate(s) is justified	-	-	-	+
(25) An explanation is given if costs or benefits are not discounted	-	-	NA	NA
(26) Details of statistical tests and confidence intervals are given for				
stochastic data	NA	NA	NA	NA
(27) The approach to sensitivity analysis is given	+	+	+	NA
(28) The choice of variables for sensitivity analysis is justified	+	-	+	NA
(29) The ranges over which the variables are varied are stated	+	+	+	NA
(30) Relevant alternatives are compared	+	+	+	+
(31) Incremental analysis is reported	+	NA	+	NA
(33) The answer to the study question is given	+	+	+	+
(34) Conclusions follow from the data reported	+	+	+	+
(35) Conclusions are accompanied by the appropriate caveats	+/-	-	+/-	+/-
36. Were generalisability issues addressed?	+/-	+/-	+/-	+/-

6.5 Discussion:

6.5.1 Summary of findings

The present study is the first review of the financial effects of EP systems in secondary care. Despite the relatively widespread uptake of EP in the secondary care setting, only a few publications have evaluated the economics of this technology within this context. Seven papers met the predetermined inclusion criteria of this literature review. On the whole, the studies identified varied significantly in terms of design and quality. Despite limiting the selection criteria to include papers reporting the economic impact of EP in secondary care institutions, considerable heterogeneity remained in the studies identified. Interventions assessed varied and often the EP systems were not described in detail. This hinders accurate interpretation of the findings reported. Moreover, the full financial impact was not measured in most studies. Only three studies conducted a full economic evaluation, the reminder performed cost analysis. Few papers reported the upfront costs of the technology implemented as well as the net economic impact due to savings.

Measures assessed for financial impact differed among the papers published. Some of the studies looked at marginal saving measures such as cutting down paper consumption or reduction in administrative man power required for transcribing. Some of the studies estimated costs of medication errors or ADEs averted. Hidden costs and potential savings were not taken fully into account in majority of the studies identified. Most of the papers reported reduction of resources used like laboratory tests or imaging. However, these were not translated into monetary values. Some studies looked into quality and safety parameters like LOS, readmission rates, mortality or medication errors however, the authors failed to quantify the effect of system use on them. The majority of the raw information about costing reported or measures assessed were based on data obtained either from the literature and/or experts' estimates. Therefore these data were not necessarily accurate. The effect of inflation and currency value was not taken into account or assumed to be stable over time in all of the studies identified.

The present review also showed that the level of CDSSs was often not described in published economic evaluations of EP and CPOE. Such information is important for any meaningful assessment of benefits as the level and maturity of CDSSs is likely to have an influence on costs and benefits achieved. Moreover, systems continue to evolve over time and consequently any benefits are likely to be incremental. Therefore the level of evidence is weak and not sufficiently robust to establish clear recommendations.

6.5.2 Comparison of the review to previous reviews published in the literature

The findings of the present review are consistent with previous reviews conducted in the area of HIT (AHRQ, 2011; Shekelle and Goldzweig, 2009; O'Reilly et al, 2012; Bassi and Lau, 2013). There are issues surrounding the reliability and quality of the methods used in published economic evaluations. The choice of economic evaluation type in relation to the research question was not justified by the authors in any of the studies included in the present

review. Hidden costs and potential savings were not taken fully into account in all the studies. In some cases, costing data were obtained from the literature and/or expert estimates which might not be appropriate for the setting concerned. Moreover, the effect of inflation and currency value was not taken into account or assumed to be stable over time in one of the studies identified. Furthermore, justification for the choices of currency rates and discounting was often not given. Generalisability issues were not appropriately addressed which makes extrapolating evidence from literature to other settings difficult.

6.5.3 Implications for clinical practice:

This section discusses the implication of the review findings on healthcare institutions' decisions as well as policy makers. Adopting new technology such as EP systems in hospital setting needs to be driven by formal evaluations. Similar to other HIT, EP system's implementation is context dependent. Therefore, policy makers should ideally refer to high quality evidence generated from similar institutions which adopted comparable technologies. There was only one evaluation identified which presented a decision model of a UK based hospital. Therefore, extrapolating evidence to the general UK setting is challenging.

The present review shows that the literature evaluating the economic impact of such systems is limited. There seem to be some elements of financial benefits when implementing EP systems in secondary care. However, it is not clear if this evidence is consistent and transferable in other similar

settings. The variability and insufficiency of evidence found in the literature makes it very difficult to highlight to which extent this knowledge is generalisable. There is little research output addressing implementation economic evaluations as these projects tend to raise unique local issues (Cairns, 1998). Moreover, the expected financial impact depends on several factors including successful implementation, training, as well as the correct use of technology in practice. Therefore, institutions should channel their efforts to identify a suitable EP system and ensure successful adoption. Furthermore, EP economic evaluation studies are challenging due to the diffuse effect of EP on many clinical processes across an institution (Lilford et al, 2010). The present review shows that studies exploring the economic impact of EP in this context are scarce. This is further complicated by quality issues and the lack of transparency in reporting methods as well as assessment of only a limited range of variables related to EP use. Further research is required to establish if EP use in secondary care is good value for money. Systems software capabilities and costs continue to change, therefore providing details of the systems evaluated including software versions and decision support capabilities is essential in this field. The findings of the present review establish that planning for concurrent prospective economic evaluations before system implementation is vital to capture expected benefits and to inform policy makers. Therefore, involvement of experts in the field such as health economists at an early stage of systems implementation is advisable.

6.5.4 Limitations for this review:

Firstly, despite the rigorous database search strategy, there might have been papers that were not included in this review, particularly grey literature, as some economic studies do not get published in peer reviewed journals and are used for local business cases. Secondly, there might have been some selection bias because of excluding publications which were the full text not written in English. Thirdly, the number of papers included in this study is rather small. This is partially due to the scarcity of economic evaluations in this field. However, the narrow selection criteria implemented in this review may also have contributed to this low yield. Fourthly, in most of the studies where CPOE were used for ordering more than just medicines, it was not possible to establish the economic outcomes specifically related to medicines unless authors reported this separately, therefore, this affected interpretation of the findings. Consequently, the researcher opted to report only studies assessing financial outcomes related specifically to medicines in a publication as this is the best of available evidence (paper under review).

Finally, given the variability of the study design, measures assessed, and the poor quality of costing data, it was difficult to combine the results of this review and synthesise them and come to generalisable conclusions

6.6 Conclusion:

Healthcare institutions need to be aware of the limitations of economic evaluations and modelling of technology. No matter how sophisticated these evaluations are, there will always remain unrealised elements of savings due to their implementation. Measuring the financial benefits of EP systems is rather difficult unless these systems are linked to administrative and operational systems that capture financial data in real time and are capable of measuring efficiency, quality and clinical performance (Frisse, 2006).

Despite the controversial economic findings in the articles, the pool of evidence seems to suggest that there are potential financial benefits, particularly if indirect costs and/or societal health gains are considered. EP systems use may provide value to patients through reducing errors, improving quality, auditing, and increasing efficiency. However, it is difficult to reach any definitive conclusion as to whether EP provides value for money due to the uncertainty surrounding the cost and outcomes, and the limited study designs available in the literature. Moreover, extrapolating the evidence to the UK context is difficult given the lack of studies conducted in the UK. I argue that ensuring better quality and reporting in future economic evaluations are necessary to fill the knowledge gap and inform policy makers' future decisions. There are guidelines published to ensure quality assessment of evaluations and reviews in this area (CRD, 2008; Philip et al, 2004). Moreover, involvement of health economists at the stage of methodology design could help inform researchers about the best approach to conduct the evaluations in relation to the research questions

Chapter 7 Overall thesis discussion

The present thesis sought to explore the landscape of EP systems use in UK NHS hospitals. A series of qualitative and quantitative studies were presented in previous chapters. Although distinct in their nature, the studies were logically connected and assembled around three central themes: the uptake, challenges and benefits of EP systems use. This final chapter aims to summarise the studies presented earlier and provide a synthesis of the overall research. The chapter starts with reiterating and linking the main findings of the studies presented in earlier chapters. This is followed by discussing the implications of the research findings on current UK practice. Overall strengths and limitations of the research are then presented, followed by future research recommendations and overall conclusions.

7.1 Overall discussion

7.1.1 The landscape of EP systems use in UK hospitals

Deployment of EP systems in English secondary healthcare sector has increased over the past two decades. Nevertheless, EP deployment has been slow and more importantly the use EP in NHS hospitals has been patchy. The survey presented in chapter two showed that the use of EP systems in acute NHS hospitals has increased. The majority of respondent hospitals had some form of EP in use but only one hospital reported a hospital-wide EP system in all clinical areas including both inpatients and outpatients. The use of inpatient EP systems was relatively rare. Conversely, the use of EP systems for discharge prescribing and chemotherapy prescribing was common. This finding was not surprising as cancer care and improving communication between primary and secondary care were two of the main areas targeted by UK EP initiatives (DoH, 2000a; Audit Commission 2001; Macmillan Cancer Support, 2012; RPS, 2011).

What has been shown for the first time is the diversity of EP systems used in NHS hospitals. There were 60 different systems in use at the time of the survey. Not only did hospitals have different EP systems, but the use of the same systems varied between different hospitals. Variations occurred in the systems' functionalities used, in the comprehensiveness of prescribing as well as the clinical pathways in which these systems were utilised. Such wide diversity in EP systems may potentially introduce risk. Moreover, the findings of the study presented in chapter two and the literature demonstrates that arguably hospital EP systems are not used to their full capacity (Metzger et al, 2010; Ahmed et al, 2013).

Hybrid prescribing systems are also being used in NHS hospitals (chapter two). Paper charts were used for prescribing specific medications such as insulin and warfarin which were challenging to prescribe electronically. Patient's medication records may therefore be split between electronic and paper media, with risks of medication prescribed on paper only being overlooked. This is an alarming finding as these were high risk medications and the use of concomitant paper systems is a major concern. Moreover, hospitals often had multiple EP systems operating concurrently. A study exploring the phenomenon of multiple EP systems use revealed that multiple EP system's use was not strategically planned (chapter three). There were various models for EP systems adoption operating concurrently in NHS hospitals. Therefore, system governance and IT involvement varied

Page 243 of 305

considerably between multiple systems within a given hospital. The study revealed also that multiple systems use resulted in many global drawbacks affecting healthcare professionals and impacting on patients' safety. Hospitals developed workarounds and initiatives to mitigate some of the negative aspects of multiple systems use. On the other hand, multiple systems use in the context of discrete speciality systems offered some benefits. However, they also introduced risks because of creating "black holes" in patients' records. Healthcare professionals may miss key information as they may not be able to obtain a full view of their patients' records. This may be due to restricted access and/or lack of awareness of discrete systems.

Undoubtedly, past EP targeted initiatives and investments had great impact to drive technology adoption in the UK health sector. Nevertheless, these initiatives and investments operated under a shifting governmental IT strategy. The UK government oscillated between two opposite approaches to IT adoption resulting in diverse and patchy technology use, such as EP, in NHS hospitals (National Audit Office 2011; NIB, 2014).

7.1.2 Adoption of integrated ePMA systems

This section draws key learning from a case study which might be relevant for other NHS hospitals implementing integrated systems.

7.1.2.1 Factors that drove systems adoption

Findings of a case study suggest that the adoption of a commercial integrated ePMA system in a UK Trust was driven by various factors (chapter five). Such factors were the realisation of ePMA benefits over paper

Page 244 of 305

prescribing, aiming to achieve integration between all clinical processes across the Trust's hospitals, as well as the needs to replace some failing IT systems. The financial incentives of the NPfIT drove the choice to implement the integrated system, rather than taking a different IT strategy (chapter five). Therefore, the ePMA stakeholders in the Trust were not directly involved in selecting the system.

7.1.2.2 Challenges of systems adoption

The integrated ePMA system implemented was perceived to be complex, rigid and not perfectly matched to UK workflows (chapters four, five). Despite these issues relating to the system implemented, stakeholders believed it had the potential to deliver numerous features they deemed to be essential. The Trust past experiences were highlighted as one of the factors influencing the integrated ePMA implementation process (chapter five). The ePMA stakeholders group had a vast experience of managing EP projects. However, the complexity of the integrated system and the large scale of the operation were perceived to be challenging. The stakeholders had to deal with shifting project timescales. The constant changes in timescale and scope were related to the project complexity as well as lack of clarity about implementation strategy within the Trust (chapters four, five). Moreover, stakeholders raised issues, related to project management, which they perceived to be challenging such as available resources, staff retention, staff attributes, and engagement of the rest of trust staff as well as documentation challenges. Furthermore, the communication between modules groups was perceived to be inadequate despite the potential global effect of each module build decision on the overall integrated system (chapter five). Difficulties

Page 245 of 305

retaining the organisational memory, due to the project complexity and challenges in documentation, may hinder future learning from such large scale implementation projects. The stakeholders identified a general working strategy and system design principles to facilitate the build of a safe and fit for purpose system. The potentially expected benefits of EP systems use is discussed next.

7.1.3 Expected benefits of EP use:

A systematic review of the economic impact of EP systems use in hospitals revealed that only a few publications have evaluated this technology within this context (chapter six). Studies were not designed to capture the full economic impact of EP system's implementation as they were often carried out retrospectively. The findings of the review presented in chapter six are consistent with previous reviews in the area of HIT. There are issues surrounding the reliability and guality of the methods used in published economic evaluations of EP systems. Hidden costs and potential savings were not taken fully into account in all the studies. In some cases, costing data were obtained from the literature and/or expert estimates which might not be appropriate for the setting concerned. Moreover, generalisability issues were not appropriately addressed which makes extrapolating evidence to other settings difficult. Often the level of CDSS was not described in published economic evaluations of EP and CPOE (chapter six). Such information is important for any meaningful assessment of benefits as the level and maturity of CDSS is likely to have an influence on costs and benefits achieved. Moreover, it was difficult to ascertain if benefits were related to medicines or other aspects of the system if CPOE systems were

evaluated. There seems to be some potential financial benefit of EP systems use in hospitals (chapter six). However the level of evidence is weak and not sufficiently robust to establish clear recommendations.

Arguably, the use of EP systems was associated with many other potential benefits (chapter one). EP systems could lead to better patient safety and improved quality through:

- Detection of potential ADE.
- Enabling better communication between healthcare providers.
- Improved coordination of healthcare delivery.
- Increased efficiency.
- Improving compliance to guidelines and best practice.

However, attaining the above mentioned benefits depends on many factors such as systems specifications, successful implementation, as well as appropriate systems use. Moreover, optimal benefits have been associated with achieving interoperability between IT systems within an organisation (Brailer, 2005; Dixon et al, 2014). The view of how to best drive EP use forward in the future is discussed in later sections.

7.1.4 Issues to be considered when conducting HIT research and interpreting its findings:

There is no single accepted way of doing research. It all depends on a range of factors including researchers beliefs about the nature of the reality they study and what can be known about it (ontology), the nature of the knowledge and how can it be acquired (epistemology), the goals of the research, and the research participants (Ritchie and Lewis, 2003). This section discusses the main issues to be considered when conducting and interpreting the findings of HIT research.

7.1.4.1 The significance of HIT research context.

Whereas relating human actions and / or events to the context in which they take place is a well-established concept in social research, it's less appreciated in other research disciplines such as HIT research and organisational change studies (Bate, 2014). However, in recent years, there is a growing body of HIT literature acknowledging and exploring research contexts (Chiasson and Davidson, 2004; Kaplan, 2001, Greenhalgh et al, 2009). Cappelli and Sherer (1991) define context as:

'... the surroundings associated with phenomena which help to illuminate that [sic] phenomena, typically factors associated with units of analysis above those expressly under investigation.'

(As cited by Bate, 2014)

The definition above establishes that phenomena cannot be understood in isolation of their context. The following section establishes aspects which make context in HIT research complex.

7.1.4.2 The complexity of HIT research context

There are three essential aspects which make context in HIT research complex, therefore difficult to study. First, there is no agreed way to define and establish context. Context was traditionally viewed as an objective phenomenon. For instance, context could be a series of events, factors or variables which may impact upon social and organisational culture (Bate, 2014). Nevertheless, modern authors argue that what is relevant is how people view and interpret context surrounding them and how that may affect their behaviour and interaction with others (Bate, 2014).

Second, organisational contexts are multi-layered. The differentiation between inner (micro) and outer (macro) organisational contexts was a major contribution made in the 1980s by Pettigrew (Pettigrew, 1985). Micro context of an organisation includes organisational and departmental cultures, leadership, champions, and organisational political processes, therefore, micro context could potentially be managed. On the contrary, macro context comprises social and political context outside an organisation therefore it cannot be controlled from an organisation's point of view. Third, context in HIT implementation research is dynamic and fluid in nature. Therefore, there is emerging prospective that researchers must account for changing contexts in their research methodologies which may require careful and creative choice of ontological, epistemological and methodological assumptions (Takian et al, 2012).

As described in chapter one, there is no universally agreed definition for EP. The findings of the present thesis establish that EP can comprise different software/systems with very different scope (chapters two, three). The findings of the qualitative work presented in this thesis also show that there are many stakeholders with varying needs involved with EP systems. Moreover, the work showed that effectiveness of EP system/s is likely to depend on other factors such as setting, system configuration, correct system use, as well as other systems in place. The studies presented in chapters four and five show that even an integrated of-the-shelf ePMA solution can be altered during system set up. Moreover, stakeholders and vendor highlighted the importance of viewing the system in another UK site and learn from their implementation's experiences. Arguably, EP is a socially and historically constructed, situated system under constant development and influenced by many other factors. EP is moulded by complex interactions between various organisational stakeholders and technology within a dynamic organisational and external political and social context. The findings of this study highlight the importance of understanding the complexity of HIT context. Future EP reports therefore should not focus on evaluating the technology and the sociotechnical aspects of the implementation in silo as implementation projects are not linear. Instead, research should view the interactions between technology and the sociotechnical aspects of implementation as a lengthy process that evolves over time. Careful considerations are required when conducting and interpreting HIT research. Constant methodological reflexivity and adaptation are essential throughout HIT evaluations. Embracing new ontological, epistemological and methodological assumptions maybe required to account for the changing context of HIT implementation (Takian et al, 2012).

7.2 A view of the future of EP in UK hospitals

Perhaps, NHS secondary care is currently at an interim stage, aiming towards achieving paperless EP and seamless patient care in the future. A sizable majority of NHS trusts surveyed planned to introduce or extend the use of EP in their hospitals (chapter two). Interviews with stakeholders from hospitals with multiple EP systems reported ongoing implementation projects of EP systems to achieve the goal of paperless prescribing. The question that every NHS trust has to answer at some point is: Should they acquire a

Page 250 of 305

fully integrated EP system or attempt to interface multiple EP systems? NHS hospitals will need to make informed choices about EP systems in order to achieve their goals. However, such decisions are complex because they are context dependent. Moreover, often hospitals will not be strategically planning for specific IT systems in isolation but a whole hospital IT strategy. Therefore, the decision about which EP system to procure might be driven by other factors not necessarily related to the system itself. Furthermore, there is little research in the context of the UK to help inform NHS hospitals and policy makers.

As described in chapter one, a report published in October 2014 proposed a new approach to achieve interoperability between NHS systems and services (NHS England, 2014). A policy paper published in November 2014 described a comprehensive framework to transform data and technology use by 2020 (NIB, 2014). The policy paper envisaged the creation of a single portal for clinical data which could be accessible through multiple channels to healthcare professionals as well as patients. Therefore, they envisaged that all care records will be digital, real-time and interoperable by 2020. Arguably, the issue of system diversity, including EP systems, must be addressed in order to attain the goals of the above mentioned framework. Therefore, NHS trusts will have to review their IT strategy and act promptly to facilitate attaining the 2020 healthcare technology vision.

7.3 Challenges of EP use in UK hospitals and implications on practice

NHS hospitals currently face two main challenges:

- How to best manage the current interim stage of multiple EP systems?
- How to drive EP systems use forward and achieve the NHS goal of interoperability by 2020?

Findings of the current thesis seem to suggest that in the interim some aspects of healthcare will be delivered via a melange of paper and EP systems (chapter two and three). Consequently, there are implications of multiple systems use, all of which were found to potentially impact on patient safety. The study presented in chapter three established some internal and external challenges that were faced by NHS hospitals in relation to multiple systems use. External challenges were related to technology itself and the current financial climate. Internal challenges were managing end-users expectations' of systems integration and providing expertise to manage, and link various EP systems.

Perhaps, the suggestion of interfacing multiple EP systems is not straightforward. Not only do systems vary in data coding and software intelligence, but there is lack of IT expertise to tackle such complex systems interfaces. Moreover, vendors have no incentives to facilitate or support interfacing systems with competitors' products. On the other hand, proposing commercial integrated EP systems as a solution to drive EP use forward is not free of challenges. Studies presented in chapters four and five established that the implementation of an 'off the shelf' fully integrated EP systems are complex and time consuming. Challenges related to the implementation approach, project management and documentation, communication with vendors, shifting of the project timelines, technical

Page 252 of 305
expertise, as well as learning from the lessons of the past were described by researchers' observation and stakeholders interviews. Overcoming all the above challenges is vital to drive technology use forward and achieve benefits.

7.4 Strengths and limitations of this research

An overall strength of the present thesis is employing both qualitative and quantitative approaches to answer the research question. The present thesis established the uptake and functionalities of EP systems in acute English NHS hospitals. The findings could be used as a baseline for any future assessment of EP systems use uptake in the NHS. The phenomenon of multiple EP systems use was described. Moreover, for the first time, an exploratory qualitative study was conducted to establish the implications of multiple EP systems use in NHS hospitals.

Overall, the present thesis had several limitations. First, the research presented in chapters (two, three, four, and five) was conducted in English NHS hospitals therefore the findings might not be representative of the rest of the UK and elsewhere. However, lessons could be extrapolated to other contexts as IT systems deployment may raise similar issues in various contexts. Moreover, practice and workflows are perhaps comparable between England and the rest of the UK. Second, this research considered the views of different stakeholders associated with EP systems deployment and use. The perspectives or views of the patients were not taken into account. Third, no specific research method can be free from methodological weaknesses. Research methods and justifications for their use were

Page 253 of 305

documented in a transparent way throughout the thesis. When appropriate, limitations specific to individual studies were highlighted in relevant chapters. An overarching limitation is the potential effect of the researchers' background as a pharmacist on the research conducted and the interpretations of the study's findings. However, while the researcher is familiar with the practice in the NHS, she is an outsider to the NHS therefore bias chances were low. Furthermore, every effort was made to reduce the effects of both personal and professional views and/or pre-conceptual ideas of the researcher on the studies.

7.5 Future recommendations for practice and policy makers:

The following recommendations for practice and policy makers are drawn from the research findings:

At a national level:

The shifting of the current government IT strategy towards a middle-out approach is recommended as this will facilitate meeting the needs not only of the government but also of all stakeholders and end-users. In a middle-out approach the government does not mandate specific systems but helps creating a common set of shared goals and underpinning standards and processes, and sometimes provides well-resourced support for standards implementation (Coiera, 2009). This approach will acknowledge that each NHS trust and hospital has different goals, starting points and resources.

Specific recommendations include:

- The establishment of a body responsible for enforcing EP system's specifications and choice. At the moment NHS hospitals do not have any recommendations clarifying which EP systems are safe, reliable and cost-effective. Moreover, providing guidance about specifications will help achieve the interoperability between IT systems and services of the NHS.
- The maintenance of a regular national census of trusts' EP systems uptake and functionalities in order to monitor the changes of systems use and the progress of reaching goals to achieve 2020 interoperability goals.
- The creation of teams of experts in the field of HIT with the aim of supporting the implementation of standards and the training of staff in individual trusts when required.
- The fostering of an environment for engagement, research and knowledge exchange in the NHS. This could be achieved by providing funds for research focusing on this area, the organisation of events where stakeholders from the NHS could share their experiences, and the provision of platforms for public involvement.

At the local level:

NHS Trusts need to review and adapt their strategies and processes in order to facilitate the acquisition, implementation and evaluation of EP systems.

Specific recommendations include:

- The formulation of clear goals for any implementation process as well as keeping the staff informed about any updates in project timelines and scope. This will ensure maintaining staff engagement throughout the process.
- The training of NHS staff to give them the skills to be able to handle large scale IT projects. This involves training in project management, providing appropriate documentation and technical expertise.
 Comprehensive training on the newly implemented technology should also be offered.
- The gap between IT provision and clinical practice should be bridged to improve the strategic planning in IT. This could be achieved by, on the one hand, integrating IT and clinical services within NHS hospitals and, on the other hand, by fostering programs to create new roles which give clinical staff the necessary skills for advanced IT operations in the NHS.
- A focus on creating interfaces for niche speciality systems such as cancer systems as these systems are likely to remain in use in the near future. However, trusts have to ensure that these systems meet all standards set to achieve interoperability.
- The planning and conducting of comprehensive evaluations for any implementation process in order to generate UK based evidence. This will allow the sharing of the acquired knowledge with other trusts implementing similar systems.

7.6 Further research endorsements:

The following research endorsements are drawn from the research findings:

- Further research to establish how to best improve learning from past IT experiences is recommended to facilitate transferring the knowledge and lessons about EP systems implementations between NHS hospitals
- Research to establish the views and perceptions of patients about EP systems use is recommended to understand the expectations and requirements of the public and to assist informed choice.

7.7 Thesis conclusions:

The present thesis established the current status of EP systems use in NHS hospitals. The findings of chapter two could be used as a baseline for any future assessment of EP systems use uptake in the NHS. The phenomenon of multiple EP systems use in NHS hospitals was described and exploratory for the first time in the present thesis.

UK secondary care IT is in an interim phase where healthcare is delivered via a melange of EP and paper systems. Recognising the implications of the systems variations on the healthcare delivery, both on the organisational and the national level, is vital to reduce clinical risk and ensure patient safety. The NHS plans to achieve seamless patient care through transforming digital data and technology use in the NHS in the near future. The task of the NHS is to manage the current interim phase and to facilitate driving the use of technology forward in NHS hospitals. Achieving interoperability between HIT systems used in the NHS is complex and presents multiple challenges. NHS

hospitals will have to make informed choices about technology deployment despite the scarce research about EP in the context of UK and the lack of comprehensive IT expertise.

The findings of the present thesis establish some of the challenges which face NHS hospitals in the context of EP deployment. Future recommendations and further research endorsement to facilitate moving EP use forward in NHS hospitals were drawn from the findings of the present thesis.

References

- AHMED, Z., MCLEOD, M. C., BARBER, N., JACKLIN, A. & FRANKLIN, B. D. 2013. The use and functionality of electronic prescribing systems in English acute NHS trusts: a cross-sectional survey. *PLoS One*, 8, e80378.
- AMMENWERTH, E., SCHNELL-INDERST, P., MACHAN, C. & SIEBERT, U. 2008. The effect of electronic prescribing on medication errors and adverse drug events: a systematic review. *J Am Med Inform Assoc,* 15, 585-600.
- AUDIT COMMISSION. 2001. NHS Cancer Care in England and Wales [Online]. Available: http://www.redcar-cleveland.gov.uk/cabpap08-09.nsf/40b8f5e614ca711f802575070057183e/\$file/nsf%20cancer%20%28a ppd%2010%29.pdf [Accessed May 2015].
- BARBER, N., FRANKLIN, B. D. & JACKLIN, A. 2013. Of snarks, boojums and national drug charts. *J R Soc Med*, 106, 6-8.
- BASSI, J. & LAU, F. 2013. Measuring value for money: a scoping review on economic evaluation of health information systems. *J Am Med Inform Assoc*, 20, 792-801.
- BATE, P. 2014. Perspectives on context: Context is everything. The health Foundation. Available: http://www.health.org.uk/sites/default/files/PerspectivesOnContextBateConte xtIsEverything.pdf [Accessed August 2015]
- BATE, P., MENDEL, P. & ROBERT, G. 2008. Organizing for quality : the improvement journeys of leading hospitals in Europe and the United States. The Nuffield Trust. Available: http://www.nuffieldtrust.org.uk/publications/organizing-quality-improvementjourneys-leading-hospitals-europe-and-united-states [Accessed August 2015]
- BATES, D. W., LEAPE, L. L., CULLEN, D. J., LAIRD, N., PETERSEN, L. A., TEICH, J. M., BURDICK, E., HICKEY, M., KLEEFIELD, S., SHEA, B., VANDER VLIET, M. & SEGER, D. L. 1998. Effect of computerized physician order entry and a team intervention on prevention of serious medication errors. *JAMA*, 280, 1311-6.
- BATES, D. W., TEICH, J. M., LEE, J., SEGER, D., KUPERMAN, G. J., MA'LUF, N., BOYLE, D. & LEAPE, L. 1999. The impact of computerized physician order entry on medication error prevention. *J Am Med Inform Assoc,* 6, 313-21.
- BAZELEY, P. 2013. *Qualitative data analysis : practical strategies,* Los Angeles, SAGE.
- BELL, D. S., CRETIN, S., MARKEN, R. S. & LANDMAN, A. B. 2004. A conceptual framework for evaluating outpatient electronic prescribing systems based on their functional capabilities. *J Am Med Inform Assoc,* 11, 60-70.
- BENBASAT, I., GOLDSTEIN, D.K., MEAD, M. 1987. The Case Research Strategy in Studies of Information Systems. *MIS Quarterly* 11, 369-386.

- BEVAN, G., KARANIKOLOS, M., EXLEY, J., NOLTE, E., CONNOLLY, S., MAYS, N. 2014. The four health systems of the United Kingdom: how do they compare? Summary report.: The Health Foundation and Nuffield Trust, London. Available: http://www.nuffieldtrust.org.uk/sites/files/nuffield/140411_four_countries_hea lth systems full report.pdf [Accessed June 2015]
- BLACK, A. D., CAR, J., PAGLIARI, C., ANANDAN, C., CRESSWELL, K., BOKUN, T., MCKINSTRY, B., PROCTER, R., MAJEED, A. & SHEIKH, A. 2011. The impact of eHealth on the quality and safety of health care: a systematic overview. *PLoS Med*, 8, e1000387.
- BOEIJE, H. R. 2010. Analysis in Qualitative Research, London, Sage.
- BOWER, A. 2005. The diffusion and value of healthcare information technology. . *RAND Corporation monograph series.* Rand Health. Available: http://www.rand.org/content/dam/rand/pubs/monographs/2006/RAND_MG27 2-1.pdf [Accessed June 2015]
- BOYATZIS, R. E. 1998. *Transforming qualitative information : thematic analysis and code development,* Thousand Oaks, Calif ; London, Sage Publications.
- BRAILER, D. J. 2005. Interoperability: the key to the future health care system. *Health Aff (Millwood),* Suppl Web Exclusives, W5-19-W5-21.
- BRAUN, V., CLARKE, V. 2006. Using thematic analysis in psychology. *Qualitative research in psychology.*, **3**, 77-101.
- BROWN, C. & LILFORD, R. 2008. Evaluating service delivery interventions to enhance patient safety. *BMJ*, 337, a2764.
- BRYMAN, A. 2001. Social Research Methods, Oxford, Oxford University Press.
- BUNTIN, M. B., BURKE, M. F., HOAGLIN, M. C. & BLUMENTHAL, D. 2011. The benefits of health information technology: a review of the recent literature shows predominantly positive results. *Health Aff (Millwood)*, 30, 464-71.
- BUXTON, M. J., DRUMMOND, M. F., VAN HOUT, B. A., PRINCE, R. L., SHELDON, T. A., SZUCS, T. & VRAY, M. 1997. Modelling in economic evaluation: an unavoidable fact of life. *Health Econ*, 6, 217-27.
- CAIRNS, J. 1998. *Economic evaluation and health care*, Nuffield Trust. Available: http://www.nuffieldtrust.org.uk/sites/files/nuffield/publication/Economic-Evaluation-and-Health-Care.pdf [Accessed October 2013]
- CAR, J. B., A.; ANANDAN, C.; CRESSWELL, K.; PAGLIARI, C.; ET AL. 2008. The Impact of eHealth on the Quality & Safety of Healthcare. A Systematic Overview & Synthesis of the Literature. Report for the NHS Connecting for Health Evaluation Programme. Available: https://www1.imperial.ac.uk/resources/32956FFC-BD76-47B7-94D2-FFAC56979B74/ [Accessed Feb 2012]
- CARE QUALITY COMMISSION. 2009a. *Managing Patients' Medicines after Discharge from Hospital.* [Online]. Available: http://webarchive.nationalarchives.gov.uk/20101201001009/http://www.cqc.o

rg.uk/_db/_documents/Managing_patients_medicines_after_discharge_from _hospital.pdf [Accessed May 2015].

- CARE QUALITY COMMISSION. 2009b. *Managing patients' medicine after discharge – A self-assessment tool.* [Online]. Available: www.cqc.org.uk/guidanceforprofessionals/nhstrusts/reviewsandstudies/2008 /09/managingmedicines.cfm [Accessed May 2015].
- CHAUDHRY, B., WANG, J., WU, S., MAGLIONE, M., MOJICA, W., ROTH, E., MORTON, S. C. & SHEKELLE, P. G. 2006. Systematic review: impact of health information technology on quality, efficiency, and costs of medical care. *Ann Intern Med*, 144, 742-52.
- CHIASSON, M. W. & DAVIDSON, E. 2004. Pushing the contextual envelope: developing and diffusing IS theory for health information systems research. *Information and Organization*, 14, 155-188.
- COIERA, E. 2009. Building a National Health IT System from the middle out. J Am Med Inform Assoc, 16, 271-3.
- CONNECTING FOR HEALTH. 2012. Challenges and lessons learned [Online]. Available: www.connectingforhealth.nhs.uk/systemsandservices/eprescribing [Accessed February 2012].
- CONNOLY, C. 2005. Cedars-Sinai doctors cling to pen and paper; transition to electronic medical records proves difficult. . *The Washington Post, 21 March 2005*
- CORLEY, S. T. 2003. Electronic prescribing: a review of costs and benefits. *Top Health Inf Manage*, 24, 29-38.
- CORNFORD, T., DOUKIDIS, G. I., FORSTER, D. 1994. Experience with a structure, process and outcome framework for evaluating an information system. . *Omega, International Journal of Management Science* 22, 491-504.
- CORNFORD, T. HIBBERD, R.; BARBER, N. 2014. The Evaluation of the Electronic Prescription Service in Primary Care – Final Report on the Findings from the Evaluation in Early Implementer Sites Available: http://www.birmingham.ac.uk/research/activity/mds/projects/HaPS/PHEB/CF HEP/reports/projects/004.aspx [Accessed June 2015]
- CORNFORD, T. S., I.; JANI, Y.; BARBER, N.; FRANKLIN, B. D.; ET AL. 2009. ePrescribing in hospitals – challenges and lessons learned. . *Report for NHS Connecting for Health.* NHS Connecting for Health. Available: http://webarchive.nationalarchives.gov.uk/20130502102046/http://www.conn ectingforhealth.nhs.uk/systemsandservices/eprescribing/challenges/Final_re port.pdf [Access May 2012]
- COUPER, M. P. & MILLER, P. V. 2009. Web Survey Methods: Introduction. *Public Opinion Quarterly*, 72, 831-835.
- COYLE, Y. M. & BATTLES, J. B. 1999. Using antecedents of medical care to develop valid quality of care measures. *Int J Qual Health Care*, 11, 5-12.

- CRESSWELL, K., ALI, M., AVERY, A., BARBER, N., CORNFORD, T., CROWE, S., FERNANDO, B., JACKLIN, A., JANI, Y., KLECUN, E., LICHTNER, V., MARSDEN, K., MORRISON, Z., PATON, J., PETRAKAKI, D., PRESCOTT, R., QUINN, C., ROBERTSON, A., TAKIAN, A., VOUTSINA, K., WARING, J., SHEIKH, A. 2011. The long and winding road...an independent evaluation of the implementation and adoption of the National Health Service care records service (NHS CRS) in secondary care in England. Available: http://www.birmingham.ac.uk/Documents/collegemds/haps/projects/cfhep/projects/005/CFHEP005Finalreport-March2011.pdf [Accessed May 2012]
- CRESSWELL, K., COLEMAN, J., SLEE, A., WILLIAMS, R., SHEIKH, A. & EPRESCRIBING PROGRAMME, T. 2013. Investigating and learning lessons from early experiences of implementing ePrescribing systems into NHS hospitals: a questionnaire study. *PLoS One*, 8, e53369.
- CRESSWELL, K. M. & SHEIKH, A. 2014. Undertaking sociotechnical evaluations of health information technologies. *Inform Prim Care*, 21, 78-83.
- CROWE, S., CRESSWELL, K., AVERY, A. J., SLEE, A., COLEMAN, J. J. & SHEIKH, A. 2010. Planned implementations of ePrescribing systems in NHS hospitals in England: a questionnaire study. *JRSM*, 1, 33.
- CURTIS, C. E., FORD, N. G. 1997. Paperless electronic prescribing in a district general hospital. *Pharmaceutical journal,* 259, 734-735.
- DAVIDSON, E. J. 2000. Analyzing genre of organizational communication in clinical information systems. *Information Technology & People,* 13, 196 209.
- DENZIN, N. K. & LINCOLN, Y. S. 2005. *The SAGE handbook of qualitative research,* Thousand Oaks ; London, Sage Publications.
- DEPARTMENT OF HEALTH. 2000. An organisation with a memory : report of an expert group on learning from adverse events in the NHS. London. Available: http://www.aagbi.org/sites/default/files/An%20organisation%20with%20a%2 0memory.pdf [Accessed March 2013].
- DEPARTMENT OF HEALTH. 2000a. *The National Cancer Plan.* [Online]. Available: http://webarchive.nationalarchives.gov.uk/20130107105354/http://www.dh.go v.uk/prod_consum_dh/groups/dh_digitalassets/@dh/@en/documents/digital asset/dh_4014513.pdf [Accessed June 2015].

DEPARTMENT OF HEALTH. 2000b. The NHS plan: a plan for investment, a plan for reform. [Online]. Available: http://webarchive.nationalarchives.gov.uk/20130107105354/http://www.dh.g ov.uk/prod_consum_dh/groups/dh_digitalassets/@dh/@en/@ps/documents/ digitalasset/dh_118522.pdf [Accessed June 2015].

DEPARTMENT OF HEALTH. 2011. Transforming Community Services. Demonstrating and Measuring Achievement: Community Indicators for Quality Improvement. [Online]. Available: www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/documents/digital asset/dh_126111.pdf [Accessed May 2015].

- DEWALT, K. M. & DEWALT, B. R. 2002. *Participant observation : a guide for fieldworkers,* Walnut Creek, Calif. ; Oxford, AltaMira Press.
- DIXON, B. E., VREEMAN, D. J. & GRANNIS, S. J. 2014. The long road to semantic interoperability in support of public health: experiences from two states. *J Biomed Inform*, 49, 3-8.
- DOBREV, A. S., K.A.; STROETMANN, V.N.; ARTMANN, J.; JONES, T.; HAMMERSCHMIDT, R. 2008. The conceptual framework of interoperable electronic health record and ePrescribing systems. Available: http://www.ehrimpact.eu/downloads/documents/EHRI_D1_2_Conceptual_framework_v1_0 .pdf [Accessed June 2015]
- DONABEDIAN, A. 1997. The quality of care. How can it be assessed? 1988. Arch Pathol Lab Med, 121, 1145-50.
- DORNAN, T., ASHCROFT, D., HEATHFIELD, H., LEWIS, P., MILES, J., TAYLOR, D., TULLY, M., WASS, V. 2009. An in depth investigation into causes of prescribing errors by foundation trainees in relation to their medical education.: London: General Medical Council.
- DRUMMOND, M. F., SCULPHER M. J., TORRANCE G. W., O'BRIEN, B. J., STODDART, G. L. 2005. *Methods for the economic evaluation of health care programmes,* Oxford, Oxford University Press.
- DRUMMOND, M. F. & JEFFERSON, T. O. 1996. Guidelines for authors and peer reviewers of economic submissions to the BMJ. The BMJ Economic Evaluation Working Party. *BMJ*, 313, 275-83.
- EDWARDS, P., ROBERTS, I., CLARKE, M., DIGUISEPPI, C., PRATAP, S., WENTZ, R. & KWAN, I. 2002. Increasing response rates to postal questionnaires: systematic review. *BMJ*, 324, 1183.
- EDWARDS, P. J., ROBERTS, I., CLARKE, M. J., DIGUISEPPI, C., WENTZ, R., KWAN, I., COOPER, R., FELIX, L. M. & PRATAP, S. 2009. Methods to increase response to postal and electronic questionnaires. *Cochrane Database Syst Rev*, MR000008.
- EHEALTH INITIATIVE 2004. Electronic Prescribing: To ward Maximum Value and Rapid Adoption: Recommendations for Optimal Design and Implementation to Improve Care, Increase Efficiency and Reduce Costs in Ambulatory Care. Available: http://c.ymcdn.com/sites/www.azhec.org/resource/resmgr/files/erx_toward_ maximum value and.pdf [Accessed May 2015]
- EHEALTH INSIDER INTELLIGENCE. 2012. Available: http://www.ehi.co.uk/ehiintelligence/ [Accessed January 2012].

EUROPEAN COMMISSION. 2015. *eHealth Action Plan 2012-2020: Innovative healthcare for the 21st century* [Online]. Available: https://ec.europa.eu/digital-agenda/en/news/ehealth-action-plan-2012-2020-innovative-healthcare-21st-century [Accessed August 2015].

FIELDING, N. & FIELDING, J. L. 1986. *Linking data,* Beverly Hills ; London, Sage.

- FOWLIE, F., BENNIE, M., JARDINE, G., BICKNELL, S., TONER, D., CALDWELL, M. 2000. Evaluation of an electronic prescribing and administration system in a British hospital. . *The Pharmaceutical Journal*, 265.
- FRANKLIN, B. D., O'GRADY, K., DONYAI, P., JACKLIN, A. & BARBER, N. 2007. The impact of a closed-loop electronic prescribing and administration system on prescribing errors, administration errors and staff time: a before-and-after study. Qual Saf Health Care, 16, 279-84.
- FRANKLIN, B. D., REYNOLDS, M., SHEBL, N. A., BURNETT, S. & JACKLIN, A. 2011. Prescribing errors in hospital inpatients: a three-centre study of their prevalence, types and causes. *Postgrad Med J*, 87, 739-45.
- FRISSE, M. E. 2006. Comments on return on investment (ROI) as it applies to clinical systems. *J Am Med Inform Assoc,* 13, 365-7.
- GALE, N. K., HEATH, G., CAMERON, E., RASHID, S. & REDWOOD, S. 2013. Using the framework method for the analysis of qualitative data in multidisciplinary health research. *BMC Med Res Methodol*, 13, 117.
- GIBBS, G. R. 2007. Analysing Qualitative Data, London, Sage.
- GLASER, B. G. & STRAUSS, A. L. 1968. *The Discovery of grounded theory. Strategies for qualitative research,* London; printed in U.S.A., Weidenfeld & Nicolson.
- GOLD, R. L. 1958. Roles in Sociological Field Observations. Social Forces, 36, 217-223.
- GOLDZWEIG, C. L., TOWFIGH, A., MAGLIONE, M. & SHEKELLE, P. G. 2009. Costs and benefits of health information technology: new trends from the literature. *Health Aff (Millwood)*, 28, w282-93.
- GOUNDREY-SMITH, S. 2008. *Principles of electronic prescribing,* New York ; London, Springer.
- GREENHALGH, T., ROBERT, G., MACFARLANE, F., BATE, P. & KYRIAKIDOU, O. 2004. Diffusion of innovations in service organizations: systematic review and recommendations. *Milbank Q*, 82, 581-629.
- GREENHALGH, T., STRAMER, K., BRATAN, T., BYRNE, E., MOHAMMAD, Y. & RUSSELL, J. 2008a. Introduction of shared electronic records: multi-site case study using diffusion of innovation theory. *BMJ*, 337, a1786.
- GREENHALGH, T., STRAMER, K., BRATAN, T., BYRNE, E., RUSSELL, J., MOHAMMAD, Y., WOOD, G. 2008b. Summary care record early adopter programme: an independent evaluation by University College London. London: University College London. Available: http://discovery.ucl.ac.uk/6602/1/6602.pdf [Accessed December 2012]
- GREENHALGH, T., POTTS, H. W., WONG, G., BARK, P. & SWINGLEHURST, D. 2009. Tensions and paradoxes in electronic patient record research: a systematic literature review using the meta-narrative method. Milbank Q, 87, 729-88.

- GROSS, Z. 2002. What it means to staff when hospitals are ahead in electronic prescribing *The Pharmaceutical Journal*, 268
- HERMANN, S. A. 2010. Best-of-breed versus integrated systems. Am J Health Syst Pharm, 67, 1406, 1408, 1410.
- HILLESTAD, R., BIGELOW, J., BOWER, A., GIROSI, F., MEILI, R., SCOVILLE, R. & TAYLOR, R. 2005. Can electronic medical record systems transform health care? Potential health benefits, savings, and costs. *Health Aff (Millwood),* 24, 1103-17.
- INSTITUTE OF MEDICINE 2001. Crossing the quality chasm: a new health system for the 21st century. Washington, DC. Available: http://www.nap.edu/catalog/10027/crossing-the-quality-chasm-a-new-healthsystem-for-the [Accessed March 2013]
- JHA, A. K., DESROCHES, C. M., CAMPBELL, E. G., DONELAN, K., RAO, S. R., FERRIS, T. G., SHIELDS, A., ROSENBAUM, S. & BLUMENTHAL, D. 2009. Use of electronic health records in U.S. hospitals. *N Engl J Med*, 360, 1628-38.
- KAPLAN, B. 2001. Evaluating informatics applications--some alternative approaches: theory, social interactionism, and call for methodological pluralism. *Int J Med Inform,* 64, 39-56.
- KARNON, J., MCINTOSH, A., DEAN, J., BATH, P., HUTCHINSON, A., OAKLEY, J., THOMAS, N., PRATT, P., FREEMAN-PARRY, L., KARSH, B. T., GANDHI, T. & TAPPENDEN, P. 2008. Modelling the expected net benefits of interventions to reduce the burden of medication errors. *J Health Serv Res Policy*, 13, 85-91.
- KAUSHAL, R., JHA, A. K., FRANZ, C., GLASER, J., SHETTY, K. D., JAGGI, T., MIDDLETON, B., KUPERMAN, G. J., KHORASANI, R., TANASIJEVIC, M., BATES, D. W., BRIGHAM & WOMEN'S HOSPITAL, C. W. G. 2006. Return on investment for a computerized physician order entry system. J Am Med Inform Assoc, 13, 261-6.
- KAUSHAL, R., SHOJANIA, K. G. & BATES, D. W. 2003. Effects of computerized physician order entry and clinical decision support systems on medication safety: a systematic review. *Arch Intern Med*, 163, 1409-16.
- KELLEY, K., CLARK, B., BROWN, V. & SITZIA, J. 2003. Good practice in the conduct and reporting of survey research. *Int J Qual Health Care,* 15, 261-6.
- KIERKEGAARD, P. 2013. E-Prescription across Europe. *Health Technol.*, 3, 205–219.
- KLEIN, H. K., MYERS, M. D. 1999. A SET OF PRINCIPLES FOR CONDUCTING AND EVALUATING INTERPRETIVE FIELD STUDIES IN INFORMATION SYSTEMS. *MIS Quarterly*, 23, 67–94.
- KOHN, L. T., CORRIGAN, J. & DONALDSON, M. S. 2000. To err is human: building a safer health system. Washington, D.C.; [Great Britain]. Available: http://www.nao.org.uk/wp-content/uploads/2011/05/1012888.pdf [Accessed October 2013]

- KOPPEL, R., METLAY, J. P., COHEN, A., ABALUCK, B., LOCALIO, A. R., KIMMEL, S. E. & STROM, B. L. 2005. Role of computerized physician order entry systems in facilitating medication errors. *JAMA*, 293, 1197-203.
- KRANSDORFF, A. 1998. Corporate amnesia: keeping know-how in the company, Oxford, Butterworth-Heinemann.
- KUPERMAN, G. J. & GIBSON, R. F. 2003. Computer physician order entry: benefits, costs, and issues. *Ann Intern Med*, 139, 31-9.
- LEAPE, L. L., KABCENELL, A. I., GANDHI, T. K., CARVER, P., NOLAN, T. W. & BERWICK, D. M. 2000. Reducing adverse drug events: lessons from a breakthrough series collaborative. *Jt Comm J Qual Improv*, 26, 321-31.
- LILFORD, R. J., CHILTON, P. J., HEMMING, K., GIRLING, A. J., TAYLOR, C. A. & BARACH, P. 2010. Evaluating policy and service interventions: framework to guide selection and interpretation of study end points. *BMJ*, 341, c4413.
- LOFLAND, J., SNOW, D., ANDERSON, L., LOFLAND, L. 2005. *Analyzing social settings : a guide to qualitative observation and analysis*, Australia ; Great Britain : c2006 Wadsworth.
- LORENZI, N. M. & RILEY, R. T. 2003. Organizational issues = change. *Int J Med Inform,* 69, 197-203.
- LORENZI, N. M., RILEY, R. T., BLYTH, A. J., SOUTHON, G. & DIXON, B. J. 1997. Antecedents of the people and organizational aspects of medical informatics: review of the literature. *J Am Med Inform Assoc,* 4, 79-93.
- MACMILLAN CANCER SUPPORT. 2012. The role of cancer networks in the new NHS [Online]. Available: http://www.macmillan.org.uk/Documents/GetInvolved/Campaigns/Theroleofc ancernetworksinthenewNHS.pdf [Accessed May 2015].
- MARSHALL, C. & ROSSMAN, G. B. 1995. Designing qualitative research, Sage.
- MEKHJIAN, H. S., KUMAR, R. R., KUEHN, L., BENTLEY, T. D., TEATER, P., THOMAS, A., PAYNE, B. & AHMAD, A. 2002. Immediate benefits realized following implementation of physician order entry at an academic medical center. J Am Med Inform Assoc, 9, 529-39.
- MEKHJIAN, H. S., KUMAR, R. R., KUEHN, L., BENTLEY, T. D., TEATER, P., THOMAS, A., PAYNE, B. & AHMAD, A. 2002. Immediate benefits realized following implementation of physician order entry at an academic medical center. *J Am Med Inform Assoc,* 9, 529-39.
- METZGER, J., WELEBOB, E., BATES, D. W., LIPSITZ, S. & CLASSEN, D. C. 2010. Mixed results in the safety performance of computerized physician order entry. *Health Aff (Millwood)*, 29, 655-63.
- MITCHELL, P. H., FERKETICH, S. & JENNINGS, B. M. 1998. Quality health outcomes model. American Academy of Nursing Expert Panel on Quality Health Care. *Image J Nurs Sch,* 30, 43-6.

MOHER, D., LIBERATI, A., TETZLAFF, J., ALTMAN, D. G. & GROUP, P. 2009.

Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLoS Med*, 6, e1000097.

- MORRISSEY, J. 2003. An info-tech disconnect. Even as groups such as Leapfrog push IT as an answer to quality issues, doctors and executives say, 'not so fast'. *Mod Healthc*, 33, 6-7, 36-8, 40 passim.
- MOZAFFAR, H., WILLIAMS, R., CRESSWELL, K., MORISON, Z., SLEE, A., SHEIKH, A. 2014. Product diversity and spectrum of choice in hospital ePrescribing Systems in England. *PLoS One*, 9, e92516.
- MYERS, M. D. 1997. Qualitative Research in Information Systems. *MIS Quarterly Discovery* [Online]. Available: http://www.misq.org/skin/frontend/default/misq/MISQD_isworld/index.html. [Accessed Feb 2014]
- NAKASH, R. A., HUTTON, J. L., JORSTAD-STEIN, E. C., GATES, S. & LAMB, S. E. 2006. Maximising response to postal questionnaires--a systematic review of randomised trials in health research. *BMC Med Res Methodol,* 6, 5.
- NATIONAL AUDIT OFFICE. 2008. *The National Programme for IT in the NHS: Progress since 2006.* [Online]. Available: http://www.nao.org.uk/publications/0708/the_national_programme_for_it.asp x [Accessed October 2013].
- NATIONAL AUDIT OFFICE. 2011. The National Programme for IT in the NHS: an update on the delivery of detailed care records systems. [Online]. Available: http://www.nao.org.uk/wp-content/uploads/2011/05/1012888.pdf [Accessed October 2013].
- NATIONAL INFORMATION BOARD 2014. Personalised health and care 2020: Using Data and technology to transform outcomes for patients and citizens, A Framework for action. Available: https://www.gov.uk/government/uploads/system/uploads/attachment_data/fil e/384650/NIB_Report.pdf [Accessed June 2015]
- NHS CHOICES. 2011. Available: http://www.nhs.uk/servicedirectories/pages/acutetrustlisting.aspx [Accessed May 2011].
- NHS ENGLAND 2013. Safer Hospitals, Safer Wards: Achieving an Integrated Digital Care Record. NHS England. Available: http://www.england.nhs.uk/wp-content/uploads/2013/07/safer-hosp-saferwards.pdf [Accessed May 2015]
- NHS ENGLAND 2014. Five year forward view. Available: https://www.england.nhs.uk/wp-content/uploads/2014/10/5yfv-web.pdf [Accessed June 2015]
- NHS ENGLAND. 2015. NHS digital technology [Online]. Available: http://www.england.nhs.uk/ourwork/tsd/sst/ [Accessed June 2015].
- NIGHTINGALE, P. G., ADU, D., RICHARDS, N. T. & PETERS, M. 2000. Implementation of rules based computerised bedside prescribing and administration: intervention study. *BMJ*, 320, 750-3.

- NIHR EPRESCRIBING RESEARCH PROGRAMME. 2015. *ePrescribing toolkit for NHS hospitals* [Online]. Available: http://www.eprescribingtoolkit.com/ [Accessed January 2015].
- O'REILLY, D., TARRIDE, J. E., GOEREE, R., LOKKER, C. & MCKIBBON, K. A. 2012. The economics of health information technology in medication management: a systematic review of economic evaluations. *J Am Med Inform Assoc*, 19, 423-38.
- PATTON, M. Q. 1990. *Qualitative evaluation and research methods,* Newbury Park, Calif., Sage Publications.
- PEDERSEN, C. A., SCHNEIDER, P. J. & SCHECKELHOFF, D. J. 2011. ASHP national survey of pharmacy practice in hospital settings: prescribing and transcribing--2010. *Am J Health Syst Pharm*, 68, 669-88.
- PEDERSEN, C. A., SCHNEIDER, P. J. & SCHECKELHOFF, D. J. 2012. ASHP national survey of pharmacy practice in hospital settings: dispensing and administration--2011. *Am J Health Syst Pharm*, 69, 768-85.
- PETTIGREW, A. M. 1985. The awakening giant : continuity and change in Imperial Chemical Industries, Oxford, Blackwell.
- PHILIPS, Z., GINNELLY, L., SCULPHER, M., CLAXTON, K., GOLDER, S., RIEMSMA, R., WOOLACOOT, N. & GLANVILLE, J. 2004. Review of guidelines for good practice in decision-analytic modelling in health technology assessment. *Health Technol Assess*, 8, iii-iv, ix-xi, 1-158.
- POPE, C. & MAYS, N. 2006. *Qualitative research in health care,* Oxford, Blackwell ; London : BMJ Books.
- POPE, C., ZIEBLAND, S. & MAYS, N. 2000. Qualitative research in health care. Analysing qualitative data. *BMJ*, 320, 114-6.
- PRICEWATERHOUSECOOPERS 2013. A review of the potential benefits from the better use of information and technology in Health and Social Care. Final report to the Department of Health.: London: PricewaterhouseCoopers.
- RECKMANN, M. H., WESTBROOK, J. I., KOH, Y., LO, C. & DAY, R. O. 2009. Does computerized provider order entry reduce prescribing errors for hospital inpatients? A systematic review. *J Am Med Inform Assoc,* 16, 613-23.
- RITCHIE, J. & LEWIS, J. 2003. *Qualitative research practice : a guide for social science students and researchers,* London, Sage Publications.
- ROBSON, C. 2002. *Real world research : a resource for social scientists and practitioner-researchers,* Madden, Mass. ; Oxford, Blackwell Publishers.
- ROGERS, E. M. 2003. Diffusion of innovations, New York, N.Y., Simon & Schuster.
- ROTHSCHILD, J. 2004. Computerized physician order entry in the critical care and general inpatient setting: a narrative review. *J Crit Care*, 19, 271-8.
- SCHENSUL, S. L., SCHENSUL, J. J. & LECOMPTE, M. D. 1999. Essential ethnographic methods : observations, interviews, and questionnaires,

Walnut Creek, Calif., AltaMira Press.

- SCHIFF, G. D., AMATO, M. G., EGUALE, T., BOEHNE, J. J., WRIGHT, A., KOPPEL, R., RASHIDEE, A. H., ELSON, R. B., WHITNEY, D. L., THACH, T. T., BATES, D. W. & SEGER, A. C. 2015. Computerised physician order entry-related medication errors: analysis of reported errors and vulnerability testing of current systems. *BMJ Qual Saf*, 24, 264-71.
- SCHMUCK, R. A. 1997. *Practical action research for change,* Arlington Heights, Ill., Skylight Professional Development.
- SCOTT, A., JEON, S. H., JOYCE, C. M., HUMPHREYS, J. S., KALB, G., WITT, J. & LEAHY, A. 2011. A randomised trial and economic evaluation of the effect of response mode on response rate, response bias, and item non-response in a survey of doctors. *BMC Med Res Methodol*, 11, 126.
- SEDEN, K., KIRKHAM, J. J., KENNEDY, T., LLOYD, M., JAMES, S., MCMANUS, A., RITCHINGS, A., SIMPSON, J., THORNTON, D., GILL, A., COLEMAN, C., THORPE, B. & KHOO, S. H. 2013. Cross-sectional study of prescribing errors in patients admitted to nine hospitals across North West England. *BMJ Open*, 3.
- SHAPIRO, J. P. 2000. Industry preaches safety in Pittsburgh. U.S. News & World Report. .
- SHEKELLE, P. G., GOLDZWEIG, C. L. 2009. Costs and benefits of health information technology: an updated systematic review. London: The Health Foundation. Available: http://www.health.org.uk/sites/default/files/CostsAndBenefitsOfHealthInforma tionTechnology.pdf [Accessed June 2013]
- SHIELL, A., DONALDSON, C., MITTON, C. & CURRIE, G. 2002. Health economic evaluation. *J Epidemiol Community Health*, 56, 85-8.
- SILVERMAN, D. 2011. *Doing qualitative research : a practical handbook,* London, SAGE.
- SITTIG, D. F. & SINGH, H. 2010. A new sociotechnical model for studying health information technology in complex adaptive healthcare systems. *Qual Saf Health Care*, 19 Suppl 3, i68-74.
- SITZIA, J. & WOOD, N. 1998. Response rate in patient satisfaction research: an analysis of 210 published studies. *Int J Qual Health Care,* 10, 311-7.
- SPENCER, D. C., LEININGER, A., DANIELS, R., GRANKO, R. P. & COEYTAUX, R. R. 2005. Effect of a computerized prescriber-order-entry system on reported medication errors. *Am J Health Syst Pharm*, 62, 416-9.
- STAKE, R. E. 1995. *The art of case study research,* Thousand Oaks ; London, Sage Publications.
- STAKE, R. 2005. *Qualitative Case Studies,* in Denzin, N.K. & Lincoln, Y.S. (eds.) *The Sage Handbook of Qualitative Research* (3rd ed.). Thousand Oaks/London/New Delhi. Sage Publications.

- STONE, W. M., SMITH, B. E., SHAFT, J. D., NELSON, R. D. & MONEY, S. R. 2009. Impact of a computerized physician order-entry system. J Am Coll Surg, 208, 960-7; discussion 967-9.
- STRAUSS, A. L. & CORBIN, J. M. 1990. *Basics of qualitative research : grounded theory procedures and techniques,* Newbury Park, Calif., Sage Publications.
- SUMMERS, V. 2000. Survey of UK Trust Chief Pharmacists Views on Electronic Prescribing. [Online]. Available: http://www.astcp.scot.nhs.uk/Old_site/News/News/News%20Item%206.htm [Accessed April 2011].
- TAKIAN, A., PETRAKAKI, D., CORNFORD, T., SHEIKH, A., BARBER, N. & NATIONAL, N. H. S. C. R. S. E. T. 2012. Building a house on shifting sand: methodological considerations when evaluating the implementation and adoption of national electronic health record systems. *BMC Health Serv Res*, 12, 105.
- TARRIDE, J. E., BLACKHOUSE, G., BISCHOF, M., MCCARRON, E. C., LIM, M., FERRUSI, I. L., XIE, F. & GOEREE, R. 2009. Approaches for economic evaluations of health care technologies. J Am Coll Radiol, 6, 307-16.
- TEICH, J. M., HURLEY, J. F., BECKLEY, R. F. & ARANOW, M. 1992. Design of an easy-to-use physician order entry system with support for nursing and ancillary departments. *Proc Annu Symp Comput Appl Med Care*, 99-103.
- THE AGENCY FOR HEALTHCARE RESEARCH AND QUALITY, 2011. Enabling medication management through health information technology. *Evidence report/technology assessment*. Available: http://www.ahrq.gov/research/findings/evidence-based-reports/medmgtevidence-report.pdf [Accessed January 2012]
- THE AGENCY FOR HEALTHCARE RESEARCH AND QUALITY 2014. Computerized Provider Order Entry [Online]. Available: http://psnet.ahrq.gov/primer.aspx?primerID=6 [Accessed June 2015].
- THE CENTERS FOR MEDICARE & MEDICAID SERVICES. 2013. Medicare and Medicaid EHR Incentive Program Basics [Online]. Available: http://www.cms.gov/Regulations-and-Guidance/Legislation/EHRIncentivePrograms/Basics.html [Accessed Oct 2013].
- THE CENTRE FOR REVIEWS AND DISSEMINATION 2008. Systematic Reviews: CRD's guidance for undertaking reviews in health care. York: York Publishing Services Ltd. Available: http://www.york.ac.uk/inst/crd/pdf/Systematic_Reviews.pdf [Accessed October 2013]
- THE COCHRANE COLLABORATION. 2001. Cochrane Handbook for Systematic Reviews of Interventions. V:5.1.0 Available: http://handbook.cochrane.org/chapter_15/15_1_2_economics_and_economi c_evaluation.htm. [Accessed May 2014]
- THE HEALTH INFORMATION MANAGEMENT SYSTEMS SOCIETY 2013. Dictionary of healthcare information technology terms, acronyms, and

organizations.

- THE LIBRARY OF THE US CONGRESS. 2015. Summaries for the Medication Errors Reduction Act of 2001 [Online]. Available: https://www.govtrack.us/congress/bills/107/hr3292/summary#libraryofcongre ss [Accessed August 2015].
- THE NATIONAL PATIENT SAFETY AGENCY. 2010. Design for patient safety: guidelines for the safe on-screen display of medication information [Online]. Available: http://www.nrls.npsa.nhs.uk/resources/?EntryId45=66713 [Accessed May 2012].
- THE ROYAL PHARMACEUTICAL SOCIETY. 2011. Keeping patients safe when they transfer between care providers – getting the medicines right. A guide for all providers and commissioners of NHS services. [Online]. Available: http://www.nhs.uk/news/2011/07july/documents/transfer%20of%20care%20 organisational%20guidance%20-%20final.pdf [Accessed May 2015].
- THE U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES OFFICE OF THE NATIONAL COORDINATOR FOR HEALTH INFORMATION TECHNOLOGY. 2015. *What is health IT*? [Online]. Available: http://www.hrsa.gov/healthit/toolbox/oralhealthittoolbox/introduction/whatishe althit.html [Accessed June 2015.
- TIERNEY, W. M., MILLER, M. E., OVERHAGE, J. M. & MCDONALD, C. J. 1993. Physician inpatient order writing on microcomputer workstations. Effects on resource utilization. *JAMA*, 269, 379-83.
- VANGEEST, J. B., JOHNSON, T. P. & WELCH, V. L. 2007. Methodologies for improving response rates in surveys of physicians: a systematic review. *Eval Health Prof,* 30, 303-21.
- VERMEULEN, K. M., VAN DOORMAAL, J. E., ZAAL, R. J., MOL, P. G., LENDERINK, A. W., HAAIJER-RUSKAMP, F. M., KOSTERINK, J. G. & VAN DEN BEMT, P. M. 2014. Cost-effectiveness of an electronic medication ordering system (CPOE/CDSS) in hospitalized patients. *Int J Med Inform*, 83, 572-80.
- WOLFSTADT, J. I., GURWITZ, J. H., FIELD, T. S., LEE, M., KALKAR, S., WU, W. & ROCHON, P. A. 2008. The effect of computerized physician order entry with clinical decision support on the rates of adverse drug events: a systematic review. J Gen Intern Med, 23, 451-8.
- WU, R. C., LAPORTE, A. & UNGAR, W. J. 2007. Cost-effectiveness of an electronic medication ordering and administration system in reducing adverse drug events. *J Eval Clin Pract*, 13, 440-8.
- YIN, R. K. 2003. *Case study research : design and methods,* Thousand Oaks, Calif. ; London, SAGE.
- ZLABEK, J. A., WICKUS, J. W. & MATHIASON, M. A. 2011. Early cost and safety benefits of an inpatient electronic health record. *J Am Med Inform Assoc,* 18, 169-72.

Appendices

Appendix A: The questionnaire used for the national survey of EP systems in English NHS hospitals



Imperial College Healthcare NHS NHS Trust

Centre for Medication Safety and Service Quality

National survey of medication systems in English NHS hospitals

Thank you for taking part in this survey.

This survey aims to identify which in-patient and discharge medication systems are

currently in use across the NHS.

Your response is invaluable to us as it will contribute to the knowledge and understanding of medication systems used in the NHS, and inform future development of strategies to:

(1) reduce medication errors, (2) streamline hospital medication systems and (3) reduce wasted medications.

As a thank you for your participation, we will send you a copy of the results once the national survey is complete.

Please answer the questions in relation to the main acute hospital in your trust.

If your trust has multiple acute hospitals, please choose one of these on which to base the questionnaire.

Only one questionnaire is required for each trust.

We appreciate that you might not be familiar with all the systems used in your hospital. Please complete the questionnaire as fully as you can and feel free to ask colleagues as appropriate. There is also a 'not sure' option for some questions.

Your answers will remain confidential.

The questionnaire will take approximately 20 to 30 minutes to complete.

Please return your completed questionnaire using the freepost envelope provided

by Friday 22nd July 2011

Thank you for your time, we really appreciate it.

If you have any questions about this survey please feel free to contact us:

Monsey McLeod <u>monsey.mcleod@imperial.nhs.uk</u> TEL: 020 3313 0521 FAX: 020 3311 1342 Zamzam Ahmed <u>zamzam.ahmed@phd.pharmacy.ac.uk</u> TEL: 020 7874 1272 FAX: 020 7387 5693

	, ,		
1.	What is the name of the trust that you work in?		
2.	How many acute hospitals are there in this trust?	acute hospitals	
3.	What is the name of the hospital that you are answering this questionnaire for? Please answer the questions in relation to the main acute hospital in your trust. If your trust has multiple acute hospitals, please choose one of these on which to base the questionnaire.		
4.	What in-patient group(s) does this hospital treat?	Adults only Paediatrics only Mixed adult and paediatrics	
5.	Approximately how many in-patient wards are there in this hospital?	in-patient wards	

For this section, please exclude any intensive care, maternity and/or mental health wards in your hospital. Please answer each statement in relation to what you see **in practice** on in-patient wards in this hospital, and not what could or should happen. **Please select one option for each part of the question, unless stated otherwise.**

6. In general, a wa	rd pharmacist visits the wards:	6.	Continued.
a. twice daily, every weekday on	All wards (skip to Question 7) Most wards Some wards One ward No wards No wards	e.	rarely or never on All wards Most wards Some wards One ward No wards Not sure
b. once daily, seven days a week on	All wards (skip to Question 7) Most wards Some wards One ward No wards No wards	f. 7.	 other (please specify): All wards Most wards Some wards One ward Typically, how many hours a day is the pharmacy open in this hospital? (for in-patient medication
c. once daily, every weekday on	All wards (skip to Question 7) Most wards Some wards One ward No wards No wards No t sure		supply) a. On weekdayshours/day b. On Saturdayshours/day
d. two or three times a week on	All wards (skip to Question 7) Most wards Some wards One ward No wards No wards Not sure	8.	c. On Sundayshours/day When the in-patient pharmacy is closed, which of the following are available? (Please select all that apply) a. On call pharmacist b. Resident pharmacist c. None of the above

C: Medication supply and storage on in-patient wards.

For this section, please continue to exclude any intensive care, maternity and/or mental health wards in your hospital. Please answer each statement in relation to what you see in practice on in-patient wards in this hospital, and not what could or should happen. Please select one option for each part of the question, unless stated otherwise.

9. (i)	9. (i) In general, in-patient wards in this hospital		10. (i	10. (i) In general, non-stock medications are			
us	e:		01	rdered during pharmacy op	ening hours:		
a.	patients' own supplies (medications from home) on	All wards Most wards Some wards One ward No wards Not sure	a.	via the ward pharmacist on their ward visit	All wards Most wards Some wards One ward No wards Not sure		
b.	ward stock on	All wards Most wards Some wards One ward No wards No wards Not sure	b.	via the ward pharmacy technician on their ward visit	 All wards Most wards Some wards One ward No wards Not sure 		
C.	non-stock medications labelled for in-patient use (no directions on label) on	All wards Most wards Some wards One ward No wards No wards	c.	by contacting the ward pharmacist outside of their ward visit	All wards Most wards Some wards One ward No wards Not sure		
d.	one-stop dispensing supplies (directions on label for patient) on	All wards Most wards Some wards One ward No wards No wards Not sure	d.	by taking the drug chart to pharmacy	All wards Most wards Some wards One ward No wards Not sure		
e.	other (please specify):	 All wards Most wards Some wards One ward 	e.	by computer/ electronically	All wards Most wards Some wards One ward No wards Not sure		
9.(ii)	In your experience, which the medication supplies (a to e a commonly used on in-patient hospital? (please enter the re from above)	ree types of bove) are most t wards in your elevant letter	f.	other method(s) (please specify): 	 All wards Most wards Some wards One ward 		
	Most common: 2 nd most common: 3 rd most common:		10.(ii)	In your experience, which to f above) are most comm patient wards in your hosy the relevant letter from ab Most common:	three methods (a nonly used on in- pital? (please enter ove)		
				2 nd most common:			

11. (i) m	In your experience, w ethods are used to obt	hich of the following ain medications for in-	13. (i) th	Continued. In general, o e wards are stored in:	ral medications on
ра hd а. [b. [atient wards outside of ours? (Please select all Borrow from anoth the same ward (alr supplied from hosp Borrow from anoth	pharmacy opening that apply) er patient's supply on eady labelled and ital pharmacy) er ward (ward stock)	b.	shelves or units without doors	All wards All wards Some wards One ward No wards No wards
c d e	 Contact the on-call Obtain the medicat reserve/emergency electronic) Obtain the medicat reserve/emergency 	pharmacist ion from a ¹ drug cupboard (non- ion from ¹ drug cupboard	c.	drug trolley (non- electronic)	All wards All wards Some wards One ward No wards No wards
f. [(electronic) Other method(s) (µ	please specify):	d.	electronic drug trolley	All wards All wards Some wards One ward No wards No wards
11. (ii tc m (p	i) In your experience, w of above) are most con edications out of hour lease enter the relevan	which three methods (a monly used to obtain s in this hospital? t letter from above)	e.	electronic storage cabinet (stationary)	All wards All wards Some wards One ward No wards No wards
	Most common: 2 nd most common: 3 rd most common:		f.	fridge	All wards All wards Some wards One ward No wards No wards
12. In ; (i)	general, oral medicatic in-patient paper drug charts All wards Most wards	ns are prescribed on: (ii) in-patient electronic prescribing system All wards Most wards	g.	controlled drugs cupboard (non- electronic)	All wards All wards Some wards One ward No wards No wards
12 (i)	Some wards One ward No wards No wards Not sure	Some wards One ward No wards No wards Not sure	h.	controlled drugs cupboard (electronic)	All wards All wards Some wards One ward No wards
13. (I) а.	medicines cupboard	All wards Most wards Some wards One ward No wards No wards Not sure	i.	patient's lockable bedside cabinet	All wards All wards All wards Some wards One ward No wards No wards No tsure
				Question 13 continues	on next page

13. (i)	Continued. In general, oral the wards are stored in:	medications on	13. (ii) In your experience, where would oral medications most commonly be retrieved from <i>(a to</i>
j.	patient's bedside table or belongings	 All wards Most wards Some wards One ward No wards Not sure 	<i>I above)</i> at the time of administration in your hospital? (please enter the relevant letter from above) Most common: 2 nd most common:
k.	patient specific container located away from patient's bedside (e.g. in medication room)	All wards All wards Some wards One ward No wards No wards	3 rd most common:
I.	other location(s) (please specify): 	 All wards Most wards Some wards One ward No wards 	

D: Medication administration, policies and guidance

For this section, please continue to exclude any intensive care, maternity and/or mental health wards in your hospital. Please answer each statement in relation to what you see in practice on in-patient wards in this hospital, and not what could or should happen. Please select one option for each part of the question, unless stated otherwise.

 14. In general, regularly prescribed medications are administered on scheduled drug rounds on: All wards Most wards 	15. Continued. For oral medications that are not stored at the patient's bedside, how are the medications transported to the patient from where they are stored?
 Some wards One ward No ward Not sure 15. For oral medications that are not stored at the	c. Trolley with no locks All wards (non-electronic) Some wards One ward Not available Not sure
patient's bedside, how are the medications transported to the patient from where they are stored? a. Lockable electronic drug trolley Most wards Some wards	d. Tray/basket All wards Most wards Some wards One ward Not available Not sure
 One ward Not available Not sure b. Lockable drug trolley (non- electronic) All wards Some wards 	e. Medicines cup/oral All wards syringe Some wards One ward Not available Not sure
One ward Not available Not sure	f. Other (please specify): All wards Most wards Some wards One ward No wards No wards

16. Ex ar	cluding controlled drugs, which ny, require a double check at ad	medications, if ministration in	17	7. Wi an	hat medication administrati d guidance is there in your l	on related policies hospital?
yo se	bur hospital? (i.e. administration cond member of staff)	is checked by a		a.	Self-administration of medications by in-patient	Yes No
a.	Intravenous medications	Ves No Not sure		b.	Nil-by-mouth policy	Ves No
b.	Intravenous fluids	Yes No Not sure		c.	Intravenous administration guide	Not sure Yes No
с.	Oral chemotherapy	Yes No Not sure		d.	(hard copy) Intravenous administration guide	Not sure Yes No
d.	Parenteral chemotherapy	Ves No Not sure		e.	(electronic copy) Guidance on what to do if medication is not	Ves
e.	Doses administered to paediatric patients	Ves No Not sure		f.	available on the ward Guidance on out of hours access to medications	Ves
f.	Specific drugs (e.g. heparin, insulin, please list)	Ves No	10			Not sure
		Not sure	18.	. WI	nich of the following practic	es are routinely
				a	Administration of	
					medications by the patient's carer (e.g. parent, spouse)	No Not sure
				b.	Nurses wear an overall/sash with "Do not disturb" or similar words during drug administration	Yes No Not sure

Additional comments

19. Please tell us about any initiatives that have been implemented in your hospital to improve any of the following: pharmacy service to in-patients, medication supply and storage on in-patient wards and/or medication administration.

Please feel free to add any other comments you may have about the pharmacy service and/or medication processes in your hospital.



PART TWO

This section is about current and/or planned electronic prescribing systems at your hospital.

	E: Electronic prescribing systems					
Thinking about all in-patient and discharge services in your hospital, please answer the following questions about electronic prescribing. In this part, please also include any systems used on intensive care, maternity and mental health wards.						
 Examples of electronic prescribing systems are: Comprehensive hospital wide prescribing systems (e.g. JAC, Cerner) Speciality targeted applications/software (e.g. ChemoCare, Varian) Systems relating to a specific part of the prescribing process (Electronic discharge prescribing) 						
20. D sy	oes your hospital have any el /stem in use at the moment?	ectronic prescribing	Y [(continue to	es] Question 21) (sl	No L kip to Question 30)	
21. Is	21. Is there more than one electronic prescribing system in use in your hospital at the moment? Yes If Yes, please insert number of systems: No No Not sure					
22. Please insert the name of the electronic prescribing system(s) you have in the hospital. Examples of electronic prescribing systems are: Comprehensive hospital wide prescribing systems (e.g. JAC, Cerner) Speciality targeted applications/software (e.g. ChemoCare, Varian) Systems relating to a specific part of the prescribing process (Electronic discharge prescribing) System 1 System 2 System 3 System 4						
23. H b	ow long has the system(s) een in place?	System 1	System 2	System 3	System 4	
a. b. c. d. e.	<1 year ≥ 1 < 2 year 2 - 5 year > 5 year Not sure					
	Please add any other comm	ents you have about	the questions on this	page.		

	System 1	System 2	System 3	System 4
Prescribing for in-	Yes	Yes	Yes	Yes
patients	No No	No	No	No No
	Not sure	Not sure	Not sure	Not sure
Prescribing for	Yes	Yes	Yes	Yes
discharge	No No	No No		
	Not sure	Not sure	Not sure	Not sure
. Others , please specify				
Please add any other co	mments vou have. Ir	nsert the letter of the	point you are referrin	g to i.e. a. (comn
and name of system if n	ecessary.			
lease answer all statement	ts from (a to h) for ea	ach system you have i	in place.	
ystem you have is in				
ne use in:	System 1	System 2	System 3	System 4
Adult intensive	Not applicable	e 🔄 Not applicable	e 🔄 Not applicable	e 📃 Not appl
therapy units	All wards	All wards	All wards	All ward
	Some wards	Some wards	Some wards	Some wa
	One ward	One ward	One ward	One war
	No wards	No wards	No wards	No ward
	Not sure	Not sure	Not sure	Not sure
Paediatric intensive	Not applicable	e 🗌 Not applicable	e 🗌 Not applicable	e 🗌 Not appl
therapy units	All wards	All wards	All wards	All wards
	Some wards	Some wards	Some wards	Some wa
	One ward	One ward	One ward	One war
	One ward	One ward	One ward	One war
	One ward No wards Not sure	One ward No wards Not sure	One ward No wards Not sure	One war
Adult medical wards	One ward No wards Not sure Not applicable	One ward One wards No wards Not sure Not applicable	One ward No wards Not sure Not applicable	One war
Adult medical wards	One ward One wards No wards Not sure Not applicable	One ward No wards Not sure Not applicable All wards	One ward No wards Not sure Not applicable All wards	One ward One ward No ward Not sure One Not appl
Adult medical wards	One ward One wards No wards Not sure All wards Some wards	One ward No wards Not sure e Not applicable All wards Some wards	One ward No wards Not sure Not applicable All wards Some wards	One ward One ward No ward Not sure Not appl All ward
Adult medical wards	One ward No wards Not sure Not applicable All wards Some wards One ward	One ward No wards Not sure All wards Some wards One ward	One ward No wards Not sure All wards Some wards One ward	One war No ward Not sure Not appl All ward: Some wa
Adult medical wards	One ward No wards Not sure Not applicable All wards Some wards One ward No warde	One ward No wards Not sure Not applicable All wards Some wards One ward	One ward No wards Not sure All wards Some wards One ward No wards	One war No ward Not sure All ward: Some wa One war
Adult medical wards	One ward No wards Not sure Not applicable All wards Some wards One ward No wards Not appe	One ward No wards Not sure e Not applicable All wards Some wards One ward No wards No wards	One ward No wards Not sure Not applicable All wards Some wards One ward No wards Not apple	One war No ward Not sure All ward: One war One war Not appl One war No ward No ward No ward
Adult medical wards	One ward No wards Not sure Not applicable All wards Some wards One ward No wards No wards Not sure Not sure	One ward No wards Not sure e Not applicable All wards One wards One ward No wards No wards No wards Not sure	One ward No wards Not sure Not applicable All wards Some wards One ward No wards No wards No wards Not sure	One war No ward Not sure Not appl All ward: Some war One war No ward No sure No sure Not sure Not sure Not sure Not sure Not sure
Adult medical wards Adult surgical wards	One ward No wards Not sure Not applicable All wards One wards One ward No wards No wards Not sure All wards	One ward No wards Not sure e Not applicable All wards One wards One ward No wards No wards No tapplicable e Not applicable	One ward No wards Not sure Not applicable All wards Some wards One ward No wards No wards Not sure Not applicable Not applicable	One war No ward Not sure All ward: Some war One war No ward No ward Not sure Not appl
Adult medical wards Adult surgical wards	One ward No wards Not sure Not applicable All wards Some wards One ward No wards No wards Not sure All wards All wards	One ward No wards Not sure e Not applicable All wards Some wards One ward No wards Not sure e Not sure e Not applicable All wards	One ward No wards Not sure Not applicable All wards Some wards One ward No wards No wards Not sure Not applicable All wards	One war No ward Not sure All ward: Some war One war No ward No ward All ward: All war
Adult medical wards Adult surgical wards	One ward No wards Not sure Not applicable All wards Some wards One ward No wards Not sure Not sure All wards Some wards One ward Not sure All wards Some wards	One ward No wards Not sure e Not applicable All wards Some wards One ward No wards Not sure e Not sure e Not applicable All wards Some wards	One ward No wards Not sure Not applicable All wards Some wards One ward No wards Not sure Not sure All wards Some wards One ward Not sure All wards Some wards One ward	One war No ward Not sure Not appl All wards Some war No ward Not sure Not sure All wards All wards Some war Not sure All wards Some war Conservation Conservatio
Adult medical wards Adult surgical wards	One ward No wards Not sure Not applicable All wards Some wards One ward No wards Not sure Not sure Not applicable All wards Some wards One ward Not applicable All wards Some wards One ward	One ward No wards Not sure e Not applicable All wards One ward One ward No wards No wards Not sure e Not applicable All wards Some wards One ward Not sure e Not applicable One ward No wards One wards One ward Not wards One wards One ward Not wards One ward Not wards One ward One w	One ward No wards Not sure Not applicable All wards Some wards One ward No wards Not sure Not sure Not applicable All wards Some wards One ward Not sure e Not applicable All wards Some wards One ward	One war No ward Not sure Not appl All wards Some war No ward No ward Not sure All wards Some war Not sure All wards Some war One war One war One war One war One war One war
Adult medical wards	One ward No wards Not sure Not applicable All wards Some wards One ward No wards Not sure Not sure Not applicable All wards Some wards One ward Not sure Not applicable All wards Some wards One ward No wards No wards	One ward No wards Not sure e Not applicable All wards Some wards One ward No wards Not sure e Not applicable All wards Some wards One ward Not sure e Not applicable All wards Some wards One ward No wards No wards No wards No wards	One ward No wards Not sure Not applicable All wards Some wards One ward No wards Not sure Not sure Not applicable All wards Some wards One ward Not sure e Not applicable All wards Some wards One ward No wards No wards No wards	One war No ward Not sure Not appl All wards Some war No ward Not sure Not sure All wards Some war Not sure All wards One war One war Not sure Not appl All wards Not appl Not appl Not ward Not
Adult medical wards	One ward No wards Not sure Not applicable All wards Some wards One ward No wards Not sure Not applicable All wards Some wards One ward Not sure Not applicable All wards Some wards One ward No wards No wards No wards No wards No wards Not sure	One ward No wards Not sure e Not applicable All wards Some wards One ward No wards Not sure e Not applicable All wards Not sure e Not applicable All wards Some wards One ward Not sure e Not applicable All wards Some wards Not sure e Not applicable All wards Some wards Not sure Not sure	One ward No wards Not sure Not applicable All wards Some wards One ward No wards Not sure Not applicable All wards Some wards One ward Not sure e Not applicable All wards Some wards One ward No wards Not sure	One ward No ward Not sure Not appl All wards Some ward No ward No ward Not sure Not appl All wards Some ward Not sure Not appl All wards Some ward No ward
Adult medical wards Adult surgical wards	One ward No wards Not sure Not applicable All wards Some wards One ward No wards Not sure Not applicable All wards Some wards One ward Not sure Not applicable All wards Some wards One ward No wards Not sure Not sure Not sure Not sure	One ward No wards Not sure e Not applicable All wards Some wards One ward No wards Not sure e Not applicable All wards Some wards One ward Not sure e Not applicable One ward No wards One ward No wards Not sure e Not sure e Not applicable Not sure e	One ward No wards Not sure All wards One ward All wards One ward Not sure Not applicable All wards Not sure e Not applicable One ward No wards Not sure e Not applicable Not sure e Not applicable	One war No ward Not sure Not appl All wards Some war One war No ward Not sure Not appl All wards Some war Not sure Not sure Not appl Not sure Not appl
Adult medical wards Adult surgical wards Paediatric medical wards	One ward No wards Not sure Not applicable All wards Some wards One ward No wards Not sure Not applicable All wards Some wards One ward Not sure Not applicable All wards Some wards No wards Not sure	One ward No wards Not sure Not applicable All wards Some wards One ward Not sure e Not applicable All wards Some wards One ward Not sure e Not applicable All wards Not sure e Not sure e Not applicable All wards Not sure e Not applicable All wards	One ward No wards Not sure All wards Some wards One ward Not applicable Not avards Not sure e Not applicable All wards Some wards One ward No wards Not sure e Not applicable All wards Not sure e Not applicable All wards Not sure e Not avards Not sure e Not avards	One war No ward Not sure Not appl All wards Some war One war No ward Not sure Not appl All wards Not sure Not appl All wards Some war Not sure Not appl All wards Not sure Not appl All wards Not sure Not appl All wards Not sure All wards Not sure All wards All wards All wards Not sure All wards Not sure All wards All wards All wards All wards
Adult medical wards Adult surgical wards Paediatric medical wards	One ward No wards Not sure Not applicable All wards Some wards One ward No wards Not sure Not applicable All wards Some wards One ward No wards Not sure	One ward No wards Not sure e Not applicable All wards Some wards One ward Not applicable Not applicable All wards Not sure e Not applicable All wards Some wards One ward No wards Not sure e Not sure e Not applicable All wards Some wards Not sure e Some wards Not sure e Not applicable Some wards	One ward No wards Not sure All wards Some wards One ward Not applicable All wards Not sure e Not applicable All wards Some wards One ward Not sure e Not applicable All wards Some wards Not sure e Not applicable All wards Some wards Not sure e Not applicable All wards Some wards	One war No ward Not sure Not appl All ward: Some war One war No ward Not sure Not appl All ward: Some war Not sure Not appl All ward: Some war Not sure Some war Not sure Not sure Some war Some war Some war
Adult medical wards Adult surgical wards Paediatric medical wards	One ward No wards Not sure Not applicable All wards Some wards One ward No wards Not sure Not applicable All wards Some wards One ward No wards Not sure Not applicable All wards Some wards One ward Not sure Not sure Not sure Not applicable All wards Some wards One ward Not sure Not applicable All wards Some wards One ward	One ward No wards Not sure e Not applicable All wards Some wards One ward No wards Not applicable All wards Some wards One ward Not applicable All wards Some wards One ward No t sure e Not applicable All wards Some wards One ward No wards Not sure e Not applicable All wards Some wards One ward No wards One ward No wards Some wards One ward One ward Some wards One ward One ward One ward One wards One ward One wa	One ward No wards Not sure All wards Some wards One ward Not applicable All wards Not sure e Not applicable All wards Some wards One ward No wards Not sure e Not applicable All wards Some wards One ward Not sure e Not applicable All wards Some wards One ward Not sure e Not applicable All wards Some wards One ward Not sure e Not applicable All wards Some wards One ward One wards One wards One wards One wards One wards One ward One ward	One war No ward Not sure Not appl All wards Some war One war Not sure Not sure Not appl All wards Some war Not sure N
Adult medical wards Adult surgical wards Paediatric medical wards	One ward No wards Not sure Not applicable All wards Some wards One ward No wards Not sure Not applicable All wards Some wards One ward Not sure Not sure	One ward No wards Not sure e Not applicable All wards Some wards One ward No wards Not applicable All wards Some wards One ward Not applicable All wards Some wards One ward Not sure e Not applicable All wards Some wards One ward Not sure e Not applicable All wards Some wards One ward Not sure e Not applicable All wards Some wards One ward Not sure e Not applicable All wards Some wards One ward Not sure e Not applicable All wards Some wards One ward Not sure e	One ward No wards Not sure Not applicable All wards Some wards One ward Not applicable All wards Not applicable All wards Some wards One ward No vards Not sure e Not applicable All wards Some wards Not sure e Not applicable All wards Some wards One ward No wards Not sure e Not applicable All wards Some wards One ward No wards Not sure e	One war No ward Not sure Not appl All wards Some war One war No ward Not sure Not appl All wards Some war Not sure Not appl All wards Some war Not sure Not appl All wards Some war One war Not sure Not appl All wards Some war One war Not sure Not appl All wards Some war One war Not appl All wards Some war Not appl All wards Some war One war Not appl One war Not appl All wards Some war One war Not appl One war Not appl No

Question 25 continues on next page

25. Con	tinued. Please answer all	statements from (a f	to h) for each	system you ha	ave in place.	
The sys	tem you have is in	System 1	System 2	Syst	em 3	System 4
routine	use in:	_	_	_		_
f.	Paediatric surgical wards	 Not applicable All wards Some wards One ward No wards Not sure 	Not ap All war Some v One wa No war	plicable ds vards ard rds re	Not applicable All wards Some wards One ward No wards Not sure	 Not applicable All wards Some wards One ward No wards Not sure
g.	Cancer services	 Not applicable All wards Some wards One ward No wards Not sure 	Not ap All war Some v One wa No war No t sur	plicable ds vards ard rds re	Not applicable All wards Some wards One ward No wards Not sure	 Not applicable All wards Some wards One ward No wards Not sure
h.	Others, please specify type of wards					
	Please add any other com and name of system if neo	ments you have. Ins cessary.	ert the letter	of the point yo	ou are referring t	o i.e. a. (comment)
26 Wh	ich hest describes vour sys	tem for each statem	ent? Please a	nswer all state	ements from (a t	o f) for each
26. Whi system	ich best describes your sys vou have in place.	tem for each statem	ent? Please a	inswer all state	ements from <mark>(</mark> a t	o f) for each
26. Whi system The sys	ich best describes your sys you have in place. stem is:	tem for each statem Syst	ent? Please a tem 1	nswer all state System 2	ements from (a t System 3	o f) for each System 4
26. Whi system The systa.	ich best describes your sys you have in place. stem is: An in-house designed sys	tem for each statem Syst	ent? Please a t em 1 Yes	System 2	ements from (a t System 3	o f) for each System 4 Yes
26. Whi system The sys a.	ich best describes your sys you have in place. stem is: An in-house designed sys 'originally designed intern	tem for each statem Syst tem ally within	ent? Please a t em 1 Yes No	System 2 Yes	ements from (a t System 3 Yes No	of) for each System 4 Yes No
26. Whi system The sys a.	ich best describes your sys you have in place. stem is: An in-house designed sys 'originally designed interr the Trust'	tem for each statem Syst item ally within	ent? Please a t em 1 Yes No Not sure	System 2 Yes No Not sure	ements from (a t System 3 Yes No Not sure	of) for each System 4 Yes No Not sure
26. Whi system The sys a. b.	ich best describes your sys you have in place. stem is: An in-house designed sys 'originally designed interr the Trust' Supplied by an external s supplier	tem for each statem Syst tem ally within oftware	ent? Please a tem 1 Yes No Not sure Yes No Not sure	System 2 Yes No Ves Yes Yes No Not sure No Not sure	ements from (a t System 3 Yes No Not sure Yes No Not sure No	o f) for each System 4 Yes No Not sure Yes No No Not sure No No No No No
26. Wh system The sys a. b.	ich best describes your sys you have in place. stem is: An in-house designed sys 'originally designed interr the Trust' Supplied by an external s supplier A stand alone application 'operates without other p	tem for each statem Syst tem ally within oftware rograms'	ent? Please a tem 1 Yes No Not sure Yes No Not sure Yes No Not sure No	System 2 Yes No Yes Yes No Not sure Yes No Yes No Not sure No Not sure	ements from (a t System 3 Yes No Ves No Not sure Yes No No System No No No System No No No No System No No No No No No System No No No No No No No No No No	o f) for each System 4 Yes No Not sure Yes No Not sure Yes No Not sure Yes No Not sure No No Not sure No No No No No No No
26. Wh system The sys a. b. c. d.	ich best describes your sys you have in place. stem is: An in-house designed sys 'originally designed interr the Trust' Supplied by an external s supplier A stand alone application 'operates without other p Is linked with, or includes	tem for each statem Syst tem ally within oftware s, the	ent? Please a tem 1 Yes No Not sure Yes No Not sure Yes No Not sure Yes	System 2 Yes No Yes Yes No Not sure Yes No Yes No Not sure Yes No Yes	ements from (a t System 3 Yes No Vot sure Yes No Vot sure Yes No Ves No Vot sure Yes No Ves	o f) for each System 4 Yes No Ves No Ves No Vot sure Yes No Not sure Yes No Ves No Ves Ves Vot sure Yes Ves Ves
26. Wh system The sys a. b. c. d.	ich best describes your sys you have in place. stem is: An in-house designed sys 'originally designed intern the Trust' Supplied by an external s supplier A stand alone application 'operates without other p Is linked with, or includes pharmacy dispensing sof	tem for each statem Syst tem Dally within Oftware Syst System System	ent? Please a tem 1 Yes No Not sure Yes No Not sure Yes No Not sure Yes No Not sure Yes No	System 2 Yes No Yes Yes No Not sure Yes No Not sure Yes No Not sure Yes No Not sure Yes No Not sure	ements from (a t System 3 Yes No Vot sure Yes No Vot sure Yes No Not sure Yes No Not sure Yes No Not sure No No No No No No No No No No	o f) for each System 4 Yes No Not sure No
26. Wh system The sys a. b. c. d.	ich best describes your sys you have in place. stem is: An in-house designed sys 'originally designed intern the Trust' Supplied by an external s supplier A stand alone application 'operates without other p Is linked with, or includes pharmacy dispensing sof	tem for each statem Syst tem Dally within Oftware Syst Syst Syst Syst Syst Syst Syst Sys	ent? Please a tem 1 Yes No Not sure Yes No Not sure Yes No Not sure Yes No Not sure Yes No Not sure	System 2 Yes No Yes No Yes No Ves Yes No Not sure Yes No Not sure Yes No Not sure Yes No Not sure	ements from (a t System 3 Yes No Ves No Ves No Ves No Ves No Ves No Not sure Yes No Not sure Yes No Not sure	o f) for each System 4 Yes No Ves No Vot sure Yes No Ves No Not sure Yes No Not sure Yes No Not sure Yes No Not sure
26. Wh system The sys a. b. c. d. e.	ich best describes your sys you have in place. stem is: An in-house designed sys 'originally designed intern the Trust' Supplied by an external s supplier A stand alone application 'operates without other p Is linked with, or includes pharmacy dispensing sof Is linked to other systems	tem for each statem Syst tem Dally within oftware s, the tware s/ software in	ent? Please a tem 1 Yes No Not sure Yes No Not sure Yes No Not sure Yes No Not sure Yes No Not sure Yes	System 2 Yes No Yes Not sure Yes No Yes No Yes Yes No Yes No Yes Yes	ements from (a t System 3 Yes No Yes No Ves No Ves Ves No Ves No Ves No Ves No Ves	o f) for each System 4 Yes No Not sure Yes Yes Yes Yes Yes Yes Yes Yes Yes Ye
26. Wh system The sys a. b. c. d. e.	ich best describes your sys you have in place. stem is: An in-house designed sys 'originally designed intern the Trust' Supplied by an external s supplier A stand alone application 'operates without other p Is linked with, or includes pharmacy dispensing soft Is linked to other systems the hospital <i>e.g. laborato</i>	tem for each statem Syst tem ally within oftware orograms' s, the tware s/ software in ry reports	ent? Please a tem 1 Yes No Not sure Yes No Not sure Yes No Not sure Yes Not sure Yes Not sure Yes No Not sure Yes No Not sure	System 2 Yes No Yes No Ves Yes No Not sure Yes No Not sure Yes No Not sure Yes No Not sure Yes No Not sure	ements from (a t System 3 Yes No Yes No Yes No Yes No Yes No Not sure	o f) for each System 4 Yes No Not sure No Not sure No Not sure No Not sure
26. Wh system The sys a. b. c. d. e.	ich best describes your sys you have in place. stem is: An in-house designed sys 'originally designed interr the Trust' Supplied by an external s supplier A stand alone application 'operates without other p Is linked with, or includes pharmacy dispensing sof Is linked to other systems the hospital <i>e.g. laborato</i> Is interfaced with other t	tem for each statem Syst tem ally within oftware s, the s/ software in ry reports echnologies	ent? Please a tem 1 Yes No Not sure Yes No Not sure Yes No Not sure Yes Not sure Yes No Not sure Yes No Not sure Yes	System 2 Yes No Not sure Yes No Not sure Yes No Not sure Yes No Not sure Yes No	ements from (a t System 3 Yes No Yes No Yes No Ves Ves No Ves No Software Yes No Not sure Yes No Not sure Yes No Not sure Yes No Not sure Yes Yes Yes Yes Yes Yes Yes Yes Yes Ye	o f) for each System 4 Yes No Yes No Not sure Yes No Not sure Yes No Ves No Not sure Yes Yes Yes Yes Yes Yes Yes Yes Yes Ye
26. Wh system The sys a. b. c. d. e. f.	ich best describes your sys you have in place. stem is: An in-house designed sys 'originally designed interr the Trust' Supplied by an external s supplier A stand alone application 'operates without other p Is linked with, or includes pharmacy dispensing sof Is linked to other systems the hospital <i>e.g. laborato</i> Is interfaced with other t <i>e.g. bar-coding, electronic</i>	tem for each statem Syst tem ally within oftware s, the s, software in ry reports c pumps.	ent? Please a tem 1 Yes No Not sure Yes No Not sure Yes No Not sure Yes No Not sure Yes No Not sure Yes No Not sure Yes No Not sure	System 2 Yes No Yes No Yes No Yes No Yes No Not sure Yes No	ements from (a t System 3 Yes No Vot sure Yes No Vot sure Yes No Not sure	o f) for each System 4 Yes No Yes No Vot sure Yes No Not sure No Not sure

27. Which best describes your sy system you have in place.	ystem for each statem	ent? Please answer a	ll statements from (a	to o) for each
The system currently offers:	System 1	System 2	System 3	System 4
 Dose checking 'checks that dose is within normal dose range' 	Not applicable Yes No Not sure	Not applicable Yes No Not sure	Not applicable Yes No Not sure	Not applicable Yes No No Not sure
 b. Dose calculations e.g. calculates dose per weight, calculate infusion rate, etc. 	 Not applicable Yes No Not sure 	Not applicable Yes No No Not sure	Not applicable Yes No No Not sure	Not applicable Yes No No Not sure
c. Free text prescribing option 'i.e. typing drug name without selecting from a list of drugs'	 Not applicable Yes No Not sure 	Not applicable Yes No No Not sure	Not applicable Yes No No Not sure	Not applicable Yes No No Not sure
d. Drug interaction alerts	 Not applicable Yes No Not sure 	Not applicable Yes No No Not sure	Not applicable Yes No No Not sure	Not applicable Yes No Not sure
e. Multi level control for prescribers 'different levels of authority tailored per prescriber'	 Not applicable Yes No Not sure 	Not applicable Yes No No Not sure	Not applicable Yes No No Not sure	 Not applicable Yes No Not sure
f. Prescribing by selecting a drug from a drop down (or similar) menu	Not applicable Yes No No Not sure	Not applicable Yes No Not sure	Not applicable Yes No Not sure	Not applicable Yes No Not sure
g. Access to drug management information e.g. BNF, policies, guidelines, formulary	Not applicable Yes No No Not sure	Not applicable Yes No No Not sure	Not applicable Yes No Not sure	Not applicable Yes No Not sure
h. Allergy checker e.g. electronic alert appears on screen	Not applicable Yes No No Not sure	 Not applicable Yes No Not sure 	 Not applicable Yes No Not sure 	 Not applicable Yes No Not sure
i. Orders laboratory investigations	Not applicable Yes No No Not sure			
j. Displays laboratory results	Not applicable Yes No No Not sure	Not applicable Yes No Not sure	Not applicable Yes No Not sure	Not applicable Yes No No Not sure
 brug stock checking 'checks if formulary drugs are available or out of stock' 	Not applicable Yes No No Not sure			
l. Discharge/transfer summaries	Not applicable Yes No Not sure	Ves Not sure	Ves Not sure	Ves Not sure

Question 27 continues on next page

27. Con each sy	ntinued. Which best desc ystem you have in place.	ribes your system for	each statement? Plea	se answer all stateme	ents from (a to o) for
The sys m. n.	etem currently offers: Prompts drug administration by nursing staff Records drug administration	System 1 Not applicable Yes No Not sure Not applicable Yes No No Not applicable Yes No No Not sure	System 2 Not applicable Yes No Not sure Not applicable Yes No No Not sure	System 3 Not applicable Yes No Not sure Not applicable Yes No No Not sure Not applicable Yes No No Not sure	System 4 Not applicable Yes No Not sure Yes No No Not sure
0.	If there is any other key features of the system, please specify:				
	Please add any other co and name of system if n	omments you have. Ins necessary.	ert the letter of the p	oint you are referring	to i.e. a. (comment)
28. Wł system On the	nich best describes your s you have in place. e current system, can	system for each statem	nent? Please answer a	Ill statements from (a	to d) for each
the fo	llowing be prescribed?	System 1	System 2	System 3	System 4
a.	Continuous Intravenous infusions (IVIs)	Not applicable Yes No No Not sure	Not applicable Yes No No Not sure	Not applicable Yes No No Not sure	Not applicable Yes No Not sure
b.	Sliding scale insulin	Not applicable Yes No No Not sure	Not applicable Yes No Not sure	Not applicable Yes No Not sure	Not applicable Yes No Not sure
c.	Warfarin	Not applicable Yes No No Not sure	Not applicable Yes No No Not sure	Not applicable Yes No No Not sure	Not applicable Yes No No Not sure
d.	Tapering doses e.g. corticosteroids	Not applicable Yes No No Not sure	Not applicable Yes No No No Not sure	Not applicable Yes No No No Not sure	Not applicable Yes No No Not sure
	Please add any other co and name of system if n	omments you have. Ins necessary.	ert the letter of the p	oint you are referring	to i.e. a. (comment)

29. Which drugs (if any) are prescr	ibed on a supplementary pa	per drug chart? (Please sele	ect all that apply)
System 1	System 2	System 3	System 4
 None Continuous IVIs Insulin Warfarin Tapering doses Other (please specify) 	 None Continuous IVIs Insulin Warfarin Tapering doses Other (please specify) 	 None Continuous IVIs Insulin Warfarin Tapering doses Other (please specify) 	 None Continuous IVIs Insulin Warfarin Tapering doses Other (please specify)
Please add any other com	nents you have. Insert the n	ame of the system if necessa	iry.
30. Does your hospital intend to in	troduce a new prescribing s	ystem(s)? If Yes, when:	
No <1 year	1-2 years >2 year	Not sure	
Please add any other com	nents you have.		

31. Please provide your details below if you are happy for us to contact you in case any of your responses require further clarification. Your contact information will remain confidential.

Name:	
Role/job title:	
Email address:	
Phone number:	
Bleep number:	

32. Thank you for completing this survey. The information you have provided will help us to identify what medication systems are currently in use and will contribute to the development of future strategies to (1) reduce medication errors, (2) streamline hospital medication systems and (3) reduce wasted medications. Would you be willing to be contacted for the next stage of our research?

Yes No

Appendix B: The pre-notification letter used for the national survey of EP systems in English NHS hospitals:



Imperial College Healthcare

Centre for Medication Safety and Service Quality

Pharmacy Department Charing Cross Hospital Fulham Palace Road London W6 8RF

Chief Pharmacist,

Date

Dear Chief Pharmacist,

National Survey of Medication Systems in English NHS hospitals

We are writing to let you know that within the next two weeks, you will receive a questionnaire and be invited to participate in a National Survey of Medication Systems in NHS hospitals conducted by the Centre for Medication Safety and Service Quality.

The survey aims to identify the types of systems, processes and resources currently used for prescribing, dispensing and administration of medication in hospitals nationwide. The findings will provide a better understanding of the variations that may exist and contribute to the development of strategies to

- reduce medication errors
- · streamline hospital medication systems and
- reduce wasted medications.

We hope that you will be willing to participate.

A questionnaire will be posted to all the Chief Pharmacists at each acute NHS hospital trust in England. Your responses will provide invaluable information about your trust. We will send you a summary of the results once the study is complete, which we hope will be helpful to you locally; we will also publish in a peer reviewed journal.

In the meantime, please do not hesitate to contact us via <u>monsey.mcleod@imperial.nhs.uk</u> or telephone 0203 313 30521 if you would like any further information.

Many thanks for your time in advance. Yours faithfully,

Professors Bryony Franklin and Nick Barber, Monsey McLeod and Zamzam Ahmed (PhD students) Centre for Medication Safety and Service Quality A joint initiative between the Pharmacy Department, Imperial College Healthcare NHS Trust and The School of Pharmacy, University of London.

Appendix C: The cover letter used for the national survey of EP systems in English NHS hospitals:



Imperial College Healthcare

Centre for Medication Safety and Service Quality

Pharmacy Department Charing Cross Hospital Fulham Palace Road London W6 8RF

Chief Pharmacist
Pharmacy Department
Address

Date Dear colleague,

We would like to invite you or a deputy to contribute to a national medication safety study that we are conducting across all acute NHS hospitals in England.

The study aims to identify the types of hospital medication systems, processes and resources currently being used for prescribing, dispensing and administration of medication in hospitals nationwide. This includes the use of electronic prescribing systems, the frequency of ward pharmacy visits, access to medications during and outside pharmacy opening hours and local strategies implemented to reduce medication errors.

The findings will help us to better understand the variations that may exist between NHS hospitals and subsequently contribute to the development of future strategies to:

- Reduce medication errors
- Streamline hospital medication systems
- Reduce wasted medications

The study has been approved by The School of Pharmacy's Research Ethics Committee.

What is involved?

We would be grateful if you (or a senior pharmacist) would complete the enclosed questionnaire for the main acute hospital in your trust. It will take approximately 20 to 30 minutes. If you have more than one main acute hospital in your trust, please choose one of these on which to base the questionnaire. Please return the completed questionnaire in the stamped addressed envelope provided by Friday 22nd July 2011.

What will I get from taking part?

We will provide you with a copy of the results once the study is complete which we hope will be useful for local service evaluation and development.

On behalf of the research team, I thank you for your time. If you have any questions about the study, please do not hesitate to contact us via <u>monsey.mcleod@imperial.nhs.uk</u> or telephone 0203 313 0521.

Yours faithfully,

Professors Bryony Dean Franklin and Nick Barber, Monsey McLeod and Zamzam Ahmed (PhD students)

Centre for Medication Safety and Service Quality

A joint initiative between the Pharmacy Department, Imperial College Healthcare NHS Trust and The School of Pharmacy, University of London.

Appendix D: The follow up reminder letter used for the national survey of EP systems in English NHS hospitals:



Imperial College Healthcare

Centre for Medication Safety and Service Quality

Pharmacy Department Charing Cross Hospital Fulham Palace Road London W6 8RF

Date

Dear Chief Pharmacist,

A few weeks ago, we sent you our "National survey of medication systems in English NHS hospitals" questionnaire, by post. If you have already completed and returned the questionnaire, please accept our sincere thanks for doing so – we will look forward to receiving your responses.

If you have not yet completed the questionnaire, we would be grateful if you or a deputy would do so at your earliest convenience. Your responses will help us to better understand the variations that may exist between NHS hospitals and subsequently contribute to the development of future strategies to:

- Reduce medication errors
- Streamline hospital medication systems
- Reduce wasted medications

If you did not receive the first questionnaire, please find one included with this letter, together with a FREEPOST return envelope.

On behalf of the research team, we thank you for your time. Please feel free to contact us via <u>monsey.mcleod@imperial.nhs.uk</u> or telephone 0203 313 0521 if you have any questions about the survey.

Yours faithfully,

Professors Bryony Dean Franklin and Nick Barber, Monsey McLeod and Zamzam Ahmed (PhD students)

Centre for Medication Safety and Service Quality A joint initiative between the Pharmacy Department, Imperial College Healthcare NHS Trust and The School of Pharmacy, University of London.

Appendix E: Likelihood of interactions/overlap between systems (sites number: 36):






R003:

ICU & Chemo: Possible overlap Chemo & discharge: Possible overlap ICU & discharge: low overlap



R016:

Chemo & discharge1: Possible overlap Chemo & discharge2: Possible overlap discharge1 & discharge2: low overlap



R043

Chemo1 & discharge: Possible overlap Chemo2 & discharge: Possible overlap Chemo1 & chemo2: high overlap



R050 ICU & Chemo: Possible overlap Chemo & discharge: Possible overlap ICU & discharge: low overlap



R091

ICU & Chemo: Possible overlap Chemo & discharge: Possible overlap ICU & discharge: low overlap



R065 Chemo & discharge: Possible overlap Chemo & inpatient-discharge: Possible overlap Discharge & inpatient-discharge: high overlap



R095

ICU & Chemo: Possible overlap Chemo & discharge: Possible overlap ICU & discharge: low overlap



R069 Discharge & inpatient-discharge: high overlap ICU & inpatient-discharge: high overlap ICU & discharge: low overlap



Chemo & ICU: Possible overlap Chemo & renal: Possible overlap ICU & renal: Possible overlap



ICU & Chemo: Possible overlap Chemo & discharge1 & 2: Possible overlap Discharge1 & discharge2: Possible overlap ICU & discharge 1& 2: low overlap







R028

Appendix F: Invitation email- multiple EP systems study

Email title: Invitation - Semi structured interviews exploring the phenomenon of multiple electronic prescribing systems within a single healthcare institution

Dear XXXXXXX,

We would like to invite you to take part in an interview as a follow up to the national survey of medication systems you took part in during 2011 which was published in PLOS ONE (paper attached). You have been selected because you reported more than one electronic prescribing (EP) system in use at your hospital at the time of the survey, and specified that you would be happy to be contacted afterwards.

This present study aims to explore the phenomenon of multiple EP systems within the same hospital. This has not previously been reported in the literature but based on our survey findings, is widespread in the UK. Our objectives are to establish users' perceptions about the utility, pros and cons, and other implications of having multiple EP systems in place in the same organisation. The findings will help us to better understand this phenomenon and hopefully contribute to future planning of EP deployment nationally.

The study has been approved by UCL Research Ethics Committee.

What is involved?

A telephone interview will be conducted at a time which is convenient to you, which will last for up to 45 minutes. Everything you say will be confidential and anonymised. For further details, please refer to the attached participant information leaflet. Please let me know if you are willing to take part by Sept 5th.

On behalf of the research team, I would like to thank you for your time. If you have any questions about the study, please do not hesitate to contact us via <u>zamzam.ahmed.11@ucl.ac.uk</u>; or via telephone on 07521772395.

Yours faithfully,

Professor Bryony Dean Franklin and Dr Yogini Jani

Zamzam Ahmed (PhD student)

UCL School of pharmacy

Appendix G: Interview guide- Multiple EP systems study

Qualitative study exploring sites with multiple electronic prescribing systems: A follow up of the National Survey of EP systems in English acute and foundation trusts

	Questions	Prompts and probes
	The interviewer will briefly explain the aim of this research then ask the interviewee if they've have read the information leaflet and answer any questions they may have. Verbal consent will be then requested.	
Background	 Q1. Can you tell me a bit about your professional background? Q2. It was reported in our 2011 survey that you had more than one electronic prescribing (EP) system in the hospital; How many EP systems are currently operational within your hospital? Q3. What are these systems and in which clinical areas are they used? Q4. Are any of these systems linked to each other? 	 Current role in the trust 2008 Years of experience Previous work in other trusts Any past experience with EP either as a user or in development Which system, what aspect they use
Reasons behind having multiple systems	Q5. What were the reasons/factors leading to have more than one system?	 Prompt about legacy systems and/or specialist systems. Prompt about the 'organic growth' of the organistation. Prompt about IT role, link with clinical staff, clinical staff involvement in IT projects etc. Government policy, NHS funds example: discharge systems to meet CQUINs, funding for cancer care etc. Championship of staff in certain clinical areas
Safety aspects	Q6. Do you use any EP systems in your work? If yes, could you tell me more about that? Q7. Can you think of any groups of health care professionals using more than one system, or any patient groups requiring the use of one more system on a regular basis? DOCTORS, NURSES, PHYSIO, OC Lementicing and the strength and maximum of basis	 patient safety, staff training issues, workflow effects Prompt about clinical areas: wards where 2 systems are in use Prompt about staff e.g. locums, pharmacy weekend coverage, musing covering other wards Groups of patients or clinical scenarios: cancer patient transferred to ICU Prompt about centralised care e.g. discharge prescriptions
	DOCTORS, NURSES, PHYSIO, Q8. In your opinion, what are the strengths and weaknesses of having	 ✓ Groups of patients or clinical scenarios: cancer patransferred to ICU ✓ Prompt about centralised care e.g. discharge pressof stroke patients etc.

	-	
	more than one EP system? Q9. Have you had any concerns about prescribing/administering/dispensing (depending on the role of the staff member) through the system's because of lack of integration? Q10. Can you describe the main difficulties or challenges you've experienced so far, if any?	 ACCESS, USE, PASS WARDS, DIFFERENT SAFTEY FEATURE. Concerns about safety or effectiveness?
Why would a trust introduce/change the system?	Q11. It was reported in the survey that the trust is looking to introduce a new system. Is that still the case? If yes, could you tell me more about that? O12 Why do you think the trust is procuring/procured a new system?	 Was it add on or to replace previous systems. If to replace probe about challenges to replace multiple specialist systems
		 Probe about policy influence, champions etc depending on their response Probe if they want a 'better' system. Try to explore what makes the 'new' system better: work smoothly and efficiently Relative advantage over previous system Simplicity Compatibility with existing workflows Trialability Potential for reinvention (capacity for users to customise and adapt it
Identifying potential interviewees, and wrap up	Q13. Could you suggest or nominate any individual staff members to be invited for a similar interview? Q15. Are there any other hospitals within your trust which have more than one EP system? If so, could you suggest any person to be invited for a similar interview? O16. It there anything also would you like to tell up?	
	Quer as and e any ming ence would you like to tell like:	

Appendix H: Participant information leaflet- Multiple EP systems study

Study title: Semi structured interviews exploring the phenomenon of multiple electronic prescribing systems within a single healthcare institution

Invitation:

We would like to invite you to take part in interviews as a follow up to the national survey of medication systems you took part in during 2011. You have been selected because you reported more than one electronic prescribing (EP) system in use at your organisation at the time of the survey, and we are interested in exploring this further. Before you decide, it is important for you to understand why the interview is being done and what it will involve. Please take time to read the following information carefully and feel free to contact us if you would like more information.

What is the purpose of the study?

This study aims to explore the phenomenon of multiple EP systems within the same hospital. Our objectives are to establish the perceptions of users about the utility, pros and cons, and implications of having multiple EP systems in place. We will also be interested in any future plans to introduce new systems within your trust.

What would the study involve?

The interview will last for up to 45 minutes. A telephone interview will be conducted at a time which is convenient to you (or face to face if you are based in London). The interview will be recorded using a digital recorder and transcribed by the researcher or a professional transcription agency. Everything you say will be confidential. We may use quotes from the interviews in our report and in any resulting publications, but these will be anonymised and any identifying information will be removed. Data will be stored on an NHS secured computer and encrypted USB memory stick. Only the researchers involved in this work will have access to this information.

You do not have to take part in this study and have the right to withdraw at any point.

What happens next?

If you agree to take part, then please inform us via email. Also, please read the attached consent form and your verbal consent will be requested at the start of the interview.

Contact details:

Zamzam Ahmed Pharmacy researcher, CMSSQ, ICHNT/UCL School of Pharmacy E: zamzam.ahmed.11@ucl.ac.uk **Prof. Bryony Dean Franklin** Executive Lead Pharmacist (Research), Imperial College Healthcare NHS Trust and UCL School of Pharmacy E: <u>bryony.deanfranklin@imperial.nhs.uk</u> Dr. Yogini Jani Lead Pharmacist (Medication Safety), UCLH NHS Foundation Trust Honorary Lecturer, UCL School of Pharmacy E: yogini.jani@nhs.net

Appendix I: Consent form- used for studies in chapter three and five

Centre Number:

Study Number:

Participant Identification Number:

Title of Project:

Name of Researcher:

Version Number:

Please initial box

1.	I confirm I have read and understand the information sheet dated	
	(version) for the above study. I have had the opportunity to consider the	Г
	information, ask questions of a member of the research team and have had these	
	answered satisfactorily.	

2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason.

3. I agree to the interview being audio recorded

4. I agree to take part in the above named study.

Name of participant...... Date...... Signature......

Name of researcher/

individual obtaining consent...... Date..... Signature.....

A copy of the signed and dated consent form and the participant information leaflet should be given to the participant and retained by the researcher to be kept securely on file.

Appendix J: Detailed coding tree- multiple EP systems study

- 1 EP systems within the hospital
 - 1.1 Current EP systems
 - 1.2 Integration between systems
 - 1.3 Other systems in place (e.g. Hybrid paper)
- 2 Exposure to EP systems
 - 2.1 Interviewee's personal experience
 - 2.1.1 Past experiences
 - 2.1.2 Current Role
 - 2.1.3 Knowledge about systems in place now
 - 2.1.3.1 Its complex
 - 2.1.3.2 Too many systems to remember
 - 2.1.3.3 Only know about systems within their clinical area
 - 2.2 Clinical staff or clinical areas exposed to multiple systems
- 3 Reasons behind having EP multiple systems
 - 3.1 Internal
 - 3.1.1 Speciality system implemented for benefits other than prescribing medicines (EP is a partial element of the system)
 - 3.1.2 Speciality system use for medicines wasn't fit for purpose
 - 3.1.3 Speciality system funded by end users
 - 3.1.4 Best of breed approach
 - 3.1.5 Lack of strategic planning
 - 3.1.6 Systems grow organically
 - 3.1.7 Systems brought in to meet local requirements
 - 3.1.8 Funding
 - 3.2 External
 - 3.2.1 National Policy
 - 3.2.2 Speciality local network led
 - 3.2.3 Government fund to increase technology investment
 - 3.3 Intention was "to have a one system"
- 4 Systems management
 - 4.1 Strategic planning and system procurement
 - 4.1.1 Clinically led
 - 4.1.2 IT led
 - 4.1.3 Equal of involvement IT & Clinicians (centralised)
 - 4.1.4 System choice: Integrated system versus best of breed
 - 4.2 Upkeep and maintenance
 - 4.3 Training
 - 4.4 Working relationship between clinical departments and IT
 - 4.5 Role of IT
 - 4.5.1 IT seen as support function within the NHS
 - 4.5.2 IT not taking lead in projects
 - 4.5.3 IT not involved at discussion stage but later at procurement
 - 4.5.4 Decision not lying with IT
 - 4.5.5 IT part of EP board
- 5 Effects of having multiple systems
 - 5.1 Positive
 - 5.1.1 Bespoke systems built for purpose, safety features
 - 5.1.2 Clinical staff avoid compromises of the 'whole hospital system' approach
 - 5.1.3 Collaborations with partners for management of speciality cases (e.g. cancer network).
 - 5.2 Negative
 - 5.2.1 Access

- 5.2.1.1 Password burden
- 5.2.1.2 Weekend duty coverage
- 5.2.1.3 Hardware
- 5.2.1.4 Locum and bank staff
- 5.2.2 Training
 - 5.2.2.1 Challenge of individualising training packages for different staff
 - 5.2.2.2 Issues around induction
 - 5.2.2.2.1 Logistics
 - 5.2.2.2.2 Difficulty for staff trained
 - 5.2.2.3 Releasing staff for face to face training
 - 5.2.2.4 Resistance to e-learning packages
 - 5.2.2.5 Training locum and bank staff
- 5.2.3 Work flows
- 5.2.4 Patient safety
- 5.2.5 Issues with outliers
- 5.2.6 Duplication of work
- 5.2.7 Difficulty to interface systems
- 5.2.8 Less control on patient management when collaborations with partners (e.g. cancer network).
- 5.3 When systems are in discrete clinical areas, staff spread across several specialities are more affected by multiple systems (e.g. pharmacists, physiotherapist)
- 6 Solutions to tackle multiple systems
 - 6.1 Workarounds to ensure safety
 - 6.1.1 Dummy prescriptions to alert doctors about medicines prescribed elsewhere
 - 6.1.2 Plan to introduce single sign on system
 - 6.2 Looking into integrations as a solution for multiple systems
 - 6.3 Attempting to phase out legacy systems
- 7 Plans for system change
 - 7.1 Future EP systems or systems in pilot
 - 7.2 Motives
 - 7.2.1 Internal
 - 7.2.2 External
 - 7.3 Challenges
 - 7.3.1 Funds
 - 7.3.1.1 Business cases rejected due to the financial climate
 - 7.3.1.2 Current government fund helped procuring systems.
 - 7.3.2 Integration
 - 7.3.3 Hardware
 - 7.3.4 Staff expectations and user acceptance
 - 7.3.4.1 Difficulty phasing out legacy systems.
 - 7.3.5 More challenges when implementing a system across wide clinical areas using speciality systems.
 - 7.3.5.1 Anxiety when a new system went live
 - 7.3.5.1.1 Pharmacy staff on call as a safety net for nurses
 - 7.3.5.1.2 Issues with outliers
- 8 Systems evolve over time

Appendix K: Sample of a framework matrix- multiple EP systems study

	A : 1.1 Current EP systems	B : 1.2 Integration between systems	C: 1.3 Other systems in place (e.g. Hybrid paper)
1 : Interview 07 AG-K Site = K System number = 3 System type = EPMA	on the ICU they use Metavision, and in theatres they use EPMA (ICM)	No integration	
Role = Dr 2 · Interview 08 CH-K	Matanisian in DICU and EDMA in all but A/E		
Site = K System number = 3 System type = EPMA Role = Dr	Metavision in PICO and EPMA in all out A/E.		
3 : Interview 10 SP-K Site = K	EPR, EPMA for the whole Trust, Metavision on the PICU	No	
System number = 3 System type = EPMA Role = Nurse	TOM	No. internetion la terre anternet Theorem	TT-build in sections
	ICM: maniferentiation presenting system, part of FR. EPMA used for prescribing across the Trust, used for some outpatient clinics, expanding for the rest of outpatient and also to include PGD's, non medical prescribing and home care/home delivery services.	no mitgration between systems. There might be a report coming from metavision that could be saved in ICM.	Hyono paper system, mepatent chemotherapy prescriptions will move to Mosaiq, sliding scale insluin started off at system but then moved to paper due to safety reasons.
	EDN: electronic discharge notification.		
	Metavision: An ICU system used at paediatric critical care ward (only used for infusions and smart pumps etc) and rest of medicines will be prescribed on ICM.		
4 : Interview 01 C-K Site = K System number = 3	Mosaiq: Chemotherapy system in outpatients to be rolled into in- patient 2015.		
System type = EPMA Role = Pharmacist	Currently tendering for a system to be used in adult ITU		
5 : Interview 05 SA-K Site = K System number = 3 System type = EPMA	Metavision, iSoft in the same ward, the first is used for infusion s while the other is used for all prescriptions. Chemotherapy system.	system not linked to each other.	
Role = Pharmacist	FDMA in nations words evoluting ICUs for OPD and discharge Py	The two systems are linked in DAS	EDMA: Danas based (ICU), despansing
6 : Interview 06 NI-CW	Aria chemotherapy system	details.	aspects.
Site = CW System number = 2 System type = EPMA Role = Pharmacist		One way allergey interface (EPMA to Aria).	Chemo: paper for making doses
	EDL web ice dicharge. Dendrite, Cardiology system	No, there will be a one way interface between JAC and EDL.	
	Bluspier in Orthopedics but stopped using it for prescribing but still used for clinical documentation.		
7 : Interview 02 H-NN Site = NN	Aria for oncology. eMed for renal.		
System number = 6 System type = No EPMA Role = Pharmacist	Orsof theatres and ops and gynae. ITU use metavision.		
	Several specialty systems: Cardiology	No integration but plan is to link them all when JAC comes.	
8 : Interview 03M-NN	ICU Varian chemotherapy		
Site = NN System number = 6 System type = No EPMA Role = Pharmacist	Will implement JAC hospital wide as they have JAC in pharmacy		
	 emed, renal system used for renal patients including those on dialysis, typically an out patient system. Intellect, cardiology system purely discharge letter, has back-door function to be used for angiography and similar. Aria, Oncology system. Bluspier, a system used in orthopedies which is a theatre 	No integration, once JAC rolled out then plan to interface with sunquest.	
9 : Interview 04 JH-NN	management system but also for electronic discharge letters which was then moved to ICE.		
Site = NN System number = 6 System type = No EPMA Role = Pharmacist	 Hospital wide discharge system Sunquest ICE. Metavision for ICU and HDU JAC rolled out 		
	Trust has 3 sites, two of them are acute. these two acute sites are linked to two different cancer networks, so one hospital has chemocare and the other has Aria.	They all interface to other systems like PAS, both chemotherapy systems interface to pathology but none is linked to each other	
	EDS, across all sites.	plan to link the future $FDMA$ to FDC	
10 : Interview 09 SM-WS	ITU system in Worthing, looking to expand to rest of ITU in the trust.	pian to link the future EPWIA to EDS.	
Site = WS System number = 3 System type = No EPMA Role = Pharmacist	EPMA in all wards to be introduced in 2015.		

Appendix L: Interview guide- Implementation of integrated EHR study (chapter five)

		Relation
Interview guide questions	Follow up questions and prompts	to framework
The interviewer will briefly explain the aim of this research then ask	Follow up in brief answer or interesting point raised by the	
the interviewee if they've have read the information leaflet and	interviewee:	
answer any questions they may have. The interviewee and the interviewer will then complete and sign the consent form.	Could you tell me more about?	
	How do you feel about?	
Q1 How did you become involved in the project in Project in	Probe if they were nominated, or decided to actively get involved.	
Q2 What has your role been so far?		
Q3 Do you think you have had sufficient support and resources?	Probe if: they were compensated for their time or normal duties.	5,7
Could you tell me more about that? (depending on their answer)	Were you compensated for your time in some way?	
	How do you feel about the amount of work involved?	
	Did you have to perform your previous duties as well in addition to this new role?	
	Do you feel you were given sufficient briefing, information and training?	
Q4. Have you been involved in any previous electronic prescribing (EP) related work?	Explore if individuals from the Trust had any previous experiences in EP, etc	5
	Was that in the Trust or somewhere else? How did it go?	
	 Absorptive capacity for new knowledge 'existing experience' Leadership and management 'strong leadership' Supportive risk taking climate Effective data capture systems: timely feedback on performance' 	
74 1/7 78 01 14	✓ Slack resources: spare money, staff, space etc	15

Q5 Why do you think the Trust has decided to procure a new system?	Do you think your/the trusts' experience has influenced this implementation? If so, could you elaborate about(depending on their answer) Probe about policy influence, champions, etc depending on their response Do you think this had to do with: a. the trust wanting a better system? b. policy or government initiatives? c. campaigning for change by key staff?	1,2
	d. media influence?	
Q6 In general, what do you think are the characteristics of an effective system? Q7 Do you think these exist in the system? Could you please elaborate about?	 work smoothly and efficiently under real conditions of use Relative advantage (clear benefits over existing technologies) Simplicity Compatibility with existing values and ways of working Trialability (can be tried out on a limited basis "without obligation") Observability (benefits can be seen directly) Potential for reinvention (capacity for users to customise and adapt it 	3,4
Q8 Did you have any expectations about Cerner ePA before? Do you think that the Cerner system meets these expectations? Have you seen any demos of the system prior to the project kick-off?	Probe their perceptions of an effective system and if the system met their expectations	
Q9 How has the project in the Trust been going so far?		5,7,9

Have you had any concerns before or during this project?		
Q10 What do you think have been the main things project? Why do you think so?	Probe about communication, language, teamwork, management, documentation & flow of information, staff retention, loss of organisational memory	6,7,8,10,11
	How do you feel about the way it is being managed? What are your views about the terminology or language used especially at the earlier stages?	
	What are your views about communication and teamwork within the project?	
	Could you tell me if there were changes in the staff you worked with over time? Do you think this has influenced the work? If so, in which way?	
	Some people think IT projects in similar big organisations are complex therefore there is a risk of knowledge loss (due to complexity, documentation challenges, staff loss), Do you think this is the case with the simplementation in the trust? If so, could you elaborate on this please?	
	\checkmark Involvement and engagement of the rest of staff	
Q11 What do you think have been the main things influencing design decisions taken in? (members of the working and steering group)	What do you think these design principles were based on? Do you think the existent workflows in the trust drove the build of or the other way around? Could you tell me more about that? Have you had any concerns about prescribing or administration	7,9,12,13,14
	through the system, its likely safety or effectiveness? Could you elaborate more about that?	
	Have you had any concerns about the upkeep and maintenance of	

	the system? Could you elaborate more about that?	
Q12 What do you think about the Trust involvement in the special interest special group?	Has that influenced the at in any aspect? If so, could you tell me more?	8
Q13 Can you describe the main difficulties or challenges you've experienced so far?		9,10,11
Q14 In your opinion, what are the strengths of the project so far and what are the threats if any?	 ✓ Innovation-system fit ✓ Tension for change ✓ Balance between supporters and opponents ✓ Specific preparedness 	5,6,7,8
Q15 What have you learnt from your involvement in this project? If you were doing this work again, what would you do differently and why? What would you advise other sites implementing ??		
Q16 How has the implementation of the system in general has been going so far? What do you think the future of electronic prescribing in the Trust will be?		
Q17 Is there anything else would you like to tell me?		

Appendix M: Participant information leaflet- Implementation of integrated EHR study (chapter five)

Study title: Semi structured interviews with

Implementation stakeholders at

Invitation:

We would like to invite you to take part in interviews as part of a service evaluation project about

implementation at

Trust. You have been selected because of your involvement in the implementation process. Before you decide, it is important for you to understand why the evaluation is being done and what it will involve. Please take time to read the following information carefully and feel free to contact us if you would like more information.

What is the purpose of the study?

This study aims to explore the complexity of the implementation of the electronic prescribing system in the Trust. One of the study's objectives is to establish key elements that facilitate the implementation process to help obtain maximum benefit of the system. We will also be interested in potential challenges and barriers. A service evaluation approval has been granted by the Quality and Safety Committee for the Division of Investigative Sciences.

What would the study involve?

The interview will last for up to 60 minutes. It will be conducted face-to-face at your preferred location. However, if you prefer to have a telephone interview instead then this could be arranged. If you are happy for the interview to be recorded, we would like to do record it using a digital recorder. Alternatively, the interviewer can take detailed notes. Everything you say will be confidential. We may use quotes from the interviews in our report and in any resulting publications, but these will be anonymised and any specific information (such as job titles or work areas) which may identify you will be removed. Data will be transcribed either by myself or by a professional agency and then stored on a Trust secured computer and encrypted USB memory stick. Only staff involved in this evaluation will have access to this information.

You do not have to take part in this study and have the right to withdraw at any point.

What happens next?

If you agree to take part, then please read and sign the attached consent form.

Contact details:

Zamzam Ahmed Pharmacy researcher E: <u>zamzam.ahmed.11@ucl.ac.uk;</u> <u>zamzam.ahmed@imperial.nhs.uk;</u> Professor Bryony Dean Franklin Executive Lead Pharmacist (Research); Director, Centre for Medication Safety and Service Quality, ICHNT (E):<u>bryony.deanfranklin@imperial.nhs.uk</u>

Appendix N: Detailed coding tree- Implementation of integrated EHR study (chapter five)



			i. It's very hard to show the benefits ⁵
			ii. Some benefits will be observed straightaway ^S
			iii. Not necessarily, benefits will come as system matures ⁵
		h.	Potential for reinvention (capacity for users to customise and adapt it) *
		i.	Standardisation and supporting processes to free clinical staff for other roles ⁵
		j.	Speed of use ^s
Factors	1.	Organ	isational antecedents for innovation*
influencing		a.	Leadership and management*
implementati		b.	Effective data capture systems*
on success\$		с.	Slack resources*
		d.	Past experiences in the Trust ⁵
			i. Teething problems with previous systems piloted ^s
			ii. Past experiences are on a much smaller scale than
			iii. Staff are often frustrated with functionalities delivered of any system ^s
			iv. ePA staff had past experience of working together in similar projects ⁵
			v. Staff waiting for EP for a long time () ^s
			vi. Experience is important ⁵
	2.	Organ	isational readiness for innovation*
		a.	Balance between supporters and opponents*
			i. More supporters than opponents ⁵
			ii. There is always sceptics but not opponents ⁵
			iii. Staff are excited about change ⁵
			iv. Staff have been waiting for EP for a long time () ⁵
			v. Nurses aware about the benefits of eMAR ⁵
		b.	Specific preparedness*
			i. One can never be ready ^{\$}
	3.	The in	nplementation and routinisation process*
		a.	Appropriate change model (balance between "make it happen" and "let it emerge")
		a.	Good project management*
			i. Trust aspects ⁵
			 Structure of the project: board overseeing several modules running parallel⁵
			2. Project board focused on contracting, dealing with suppliers and BT and didn't pay enough attention to different
			steering groups ⁵
			3. Delays in ePA go-live due to delays in implementation of PAS and other modules ⁵
			 Changes in project plans (where to start, and how to roll out)⁵
			5. Communication different steering groups (e.g. EP and Clindocs) was informal therefore not adequate at

	sometimes
	6. Overall project progress ⁵
	ii. EP related aspects ⁵
	1. EP is one module of many ^s
	2. Understanding of how other modules are being designed was vital for ePA but not optimal ⁵
	3. staff had past experience of working together in similar projects ⁵
	 adopted an unusual way of working: prioritised prescribing over administration⁵
	5. Several changes in EP project managers ⁵
	6. Concerns about one of the project managers appointed ⁵
	7. EP build becomes outdated when project is delayed ⁵
	 EP team used the delay to build a more sophisticated system⁵
	 Proposal for EP to go live before the official date was rejected^s
	10. EP group was ahead therefore had less support ⁵
	11. Senior staff prioritised ClinDocs module over EP ⁵
	12. Members' interest in EP (involvement) ⁵
	13. Huge workload for EP team ⁵
	14. Overall EP progress
	iii. aspects (methodology) ⁵
	 Perception of need for extra system validation events after delays in project⁵
	2. Workload on staff and shortage in resources
	 Issues with the build (re-building the whole catalogue)⁵
	 were sometimes not very good at driving the events (system review, design review etc)⁵
	5. has learnt from the project and is changing their way of working ⁵
b.	Autonomy of frontline clinical teams*
	i. Good team work within EP ³
	ii. Good relationships with
	iii. Relationships between client and vendor was better in EP than other groups ^a
с.	Human resource factors, selection, retention, continuity, and training of staff*
	i. Expertise of the NHS staff, mainly clinical
	ii. Vendor expertise and background, mainly technical
	ii. Concerns about the quality rather than the quantity of resource
	iv. Changes in EP team
d.	Engagement of the I rust staff (not directly involved with setting up the system)"
	I. Maintain the right degree of involvement of rest of the staff
	II. Engagement was good at the start then dwindled"
	III. the Trust staff had no protected time to attend events"

	e.	Alignment between new and old routines*:
		i. Balance between making the system compatible with workflows and/or adapting workflows
		ii. The trust has to change the way it works to improve the service provided ^s
		iii. It has to be compatible with existing workflows (opposing to i) ⁵
		iv. Challenge of unifying workflows for 3 hospitals within one trust (distinction between policy and practice) ⁵
	4. Linkag	e*
	a.	Early & ongoing dialogue between the developers, the change agents, & end users*
		i. Shared understanding of the basics is important but can be very frustrating to people ⁵
		ii. Meeting of the minds (vendor and client) takes time ⁵
		iii. Terminology difference between client and vendor ⁵
		1. Language evolves over time ⁵
		2. Terminology difference was a concern at the start ⁵
		 It's important for client and vendor to understand each other⁵
	b.	Communication within the organisation and between similar organisations*
		i. Communication within EP group was great (including representative)
		 Understanding of how other modules are being designed was vital for EP but not optimal
		iii. Communication between modules was informal therefore not adequate at sometimes
		iv. role of the special interest group representing other trusts implementing (communication with other trusts
		implementing
		1. Difficulties because of the way its led
		v. Informal channels with other trusts implementing
Challenges for	1. Conc	erns of potential adapters ":
change"	a.	Iraining"
	D.	Clinical Concerns (IV Fluids and discharge)
	C.	Workload of ePA team
	a.	Quality and volume of support from vendor
	e. f	For a factilities unior doctors ⁵
	ι. σ	Pear of deskilling julion doctors
	5. h	Retartion of EP staff on the long run ⁵
		Wireless black spots in Hammersmith Hospital ⁵
	i.	Issues with the build (re-building the whole catalogue) ⁵
	j. k.	Non UK system different process, different language ⁵
		There are simpler systems used in other hospitals that work efficiently (in the source of the sourc
	m	. Similar to many EP systems, the is not designed with pharmacist workflow on mind ⁵
		i. Pharmacy ward roles ⁵
L	1	•

			ii. Interfacing with dispensary ^s		
	2.	2. Loss of organisational memory (knowledge degradation) ⁵			
		a.	Challenges in documentation ^s		
			a. Method M ^s		
		b.	Changes in staff ⁶		
	3.	3. Complexity ⁵			
		a.	Complexity of the process ⁵ :		
		b.	EP is a project managed within a project ⁵ .		
		c.	Progress of other modules affect EP progress ⁵		
		d.	Understanding of other modules are being designed was vital for EP but not optimal ⁵		
		e.	Challenge of unifying workflows for 3 hospitals (distinction between policy and practice) ⁵		
	4.	4. The project is fluid ⁵			
		a.	System is changing in the background during the project ^S		
		b.	Trust is changing: (legislations, Hardware changes, Financial position, prescribing credentials, staff) ⁵		
		c.	Vendor is changing (interest and position in the market ^s		
How to make	1.	Design principles to ensure safety and reduce risks ⁵			
sure the		a.	Has to be "not worse" than previous system (paper system) ^{\$} .		
change is		b.	Support order sentences and care sets help reduce key strokes for prescribing ⁵		
safe ⁵		с.	Standardisation and supporting processes to free clinical staff for other roles ⁵		
	2.	Workflow drive the build or system build change existing workflows ^s :			
		a.	Balance between making the system compatible with workflows and adapting workflows ^{\$}		
		b.	The trust has to change the way it works to improve the service provided ⁵		
		с.	It has to be compatible with existing workflows (opposing view to a.) ⁵		
		d.	Challenge of unifying workflows for 3 hospitals (distinction between policy and practice) ^{\$}		
	3.	Uptake	, maintenance and reporting ^S		
* Verbatim taken from the original framework					
f Taken from the o	f Taken from the original framework and amended (either rephrased or grouped or relocated under a different section)				

£ Taken from the original framework and amended (either rephrased or grouped or relocated under a different section \$ New addition to the framework

Appendix O: Sample of a framework matrix- Implementation of integrated EHR study (chapter five)

		B: 13 Workflow drive the build or	O - 14 Unitaka
	A : 12. Design principles to ensure safey and reduce risks	system build change existing	maintainance and reporting
1: Interview 8	Promution: find initially 90 drugs that covers must respective scenario, worked	A mixture of both It would have been	Concern Trust haven) planned
	at designing and building them, demonstrate how it looks, then demonstrate to	helpful to document pathways (e.g. pain	how will upkeep and
Experience EP	other staff and get decisions signed off.	management after surgery). Time was	maintenance be tackled later.
Involvement -	Involvement: demonstrate build to staff and get this signed off	wasied on trivial things.	
Level - Not	Compromise: functionality sometimes doesn't deliver what staff want then		
Applicable	consider alternative solution, making everyone satisfied that its safe and fulfils		
Role - Vendor	work pathways. Decomptions componentic income which makes it assists to do the inh	Work Gross on outdated. The system	Concerns about second for
	r regulations, programme restant without matches in cases, in our party	should change the work flows to improve	upkeep, maintenance and
2 : Intendew 1	Making a system not worse or less safe that current systems.	safety and efficiency. e.g pharmacista visita	reporting. This was flagged up.
	Increasing efficiency; Speed and case of use, reduce key strokes, making it easier	or who is on reserve antibiotic shouldn't be	
Experience EP	to prescribe the right things.	required.	
res involvement -	Immoved safety and quality outcomes through standardisation (Building care sets	Its important to to computerise current	
From the start	and order sentences to reduce key strokes). Standardisation allows staff to focus	work flows, essentially use the current	
Level - Senior	on complicated patients.	flows not recreating them, Trying to think	
Pharmacy staff	Not to design anything in catalogue which requires hard work to update it.	to improve practice.	
	Drawing from previous experience with EP (what worked and what didn't	Not much ability to diverge from the	Upkeep, maintenance will
	work), EP team knew what needed to make it work.	system, they developed workarounds or worked with the system, more worked with	always remain a worry as not
	Avoid hybrid (paper and electronic system), avoid having complex drugs	the system.	understood. Need advise from
	on paper.		Vendor to take through
3 : Interview 2	Targeting complex prescribing from the start, insulin, IVs, Oxygen, Some challenging frequencies (e.g. Q72h).		required week.
Experience EP			
- Yes	IV solution not ideal but functionality is coming on the next code level. (Trust will move to next code level quickly).		
From the start	(mar na more a new core are query).		
Level - Senior	System lack variable dosing and ability to suspend and resume drugs, IV package people improvement, pharmacu unde form (drug bicker) and		
Role - Pharmacy staff	reconciliation).		
4 : Interview 4	Make system as easy and safe as possible for users. Safety comes first, then ease	Mixture, current work flows influenced the	No Concerns about that, only
Everations EP	of use.	build, some unsuitable work flows were	concerns if system goes down.
- Yes		differently and improve.	
involvement -			
Level - Senior			
Role -			
5 Interview 3	Partly driven by what aliminians want. A lot use driven but what uses receible	System is hard-spined little could be	
	and not possible.	modified which is a negative aspect of the	Concerns about effects on
Experience EP		ay slem.	clinicians work (overriding
Involvement -			areno or reporting the system).
From the start			
Role - Doctor			
	Pragmatism and the majority, Re-Administration: Nursing involvement in	System build wasn't driven by work flows	Falls under pharmacy lead
6 : Interview 5	Er was smited, apprying oid knowledge (maybe outdated experience) then testing on Junior staff.	or trust, system is being 'manipulated' to match trust work flows.	responsibility, will probably follow the routine of similar
			work, concerns about version
Experience EP = No	nere have been not better way to do it as no precedents to follow (e.g. no body else in the UK looked at that.		control (e.g. policies).
Involvement -			
From the start	Uniting the work to managible pieces (e.g. top 100 drugs), build an example of every possible scinareo (e.g. build one example of each route		
Role - Nurse	such as eye drops).		
7 : Interview 6	Pragmatism, not worse off current system if not better.	Many of tust work flows couldn't be	A lot of maintenance work will
Experience EP	Establishing work flows and who will be impacted by the functionality, look at	were used.	doing something first which is
- Hands on now	functionalities and options, consult with all affected and users (if any) before		a concern.
Midway point	making changes and decisions.		
Level - Junior			
Role =			
Prioritiacy stati	User platform experience, making screen display relevant, accurate, simple.	Mixture, in some aspects System built	Huge maintenance task as
8 : Interview 7	Remove unnecessary information (make screen display less busy).	the system around the trust work flow,	system is very complex.
Experience EP	Most decision principles were taken before staff joined the group.	this is their work flow which needs to	There will be issues with staff
- Hands on now		be adopted.	changes, Inducting new people
Involvement - Midway point			will be take awhile.
Level - Junior			Worry about using back IT
Role -			office (relationship, and doing
Distance of the local sector of the local sect			

Appendix P: The MEDLINE database search strategy- Chapter six

1	Computeri?ed prescribing OR e medicine management OR e medicine management
2	Medication Alert System OR Medication Alert System*
3	Order entry system OR order entry System* OR computeri?ed physician order entry system
	OR computeri?ed physician order entry System* OR CPOE
4	E-Prescribing OR E Prescribing OR Electronic Prescribing OR E Prescr* OR E-Prescr* OR
	Electronic Prescr*
5	1 OR 2 or 3 OR 4
6	Cost OR Cost Analyses OR Cost Analysis OR Cost Measure OR Cost Measures OR Pricing
7	Cost-Benefit OR Cost-Benefit Analyses OR Cost Benefit Analysis OR Cost Effectiveness OR
	Cost-Benefit Data OR Cost Benefit Data OR Cost Benefit OR Cost Saving OR Health Care Cost
8	OR Healthcare Cost* OR Health Cost OR Health Cost* OR Medical Care Cost OR Medical Care
	Cost* OR Treatment Cost OR Treatment Cost* OR expenditure OR Cost Utility
9	6 OR 7 OR 8
10	5 AND 9