

“Towards a prototype and strategy for an electronic medication reconciliation capture in e-medication management systems in an Irish acute care setting”

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

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## Declaration

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

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## Summary

There is much evidence to support the practice of medication reconciliation (Med Rec) and its contribution to patient safety. Med Rec is the process whereby a complete and accurate list of a patient's medication is discerned. It occurs when a patient is at a healthcare transition e.g. moving between primary and secondary care. It involves accounting for every medication a patient is taking, and documenting decisions made by a physician to actively discontinue, continue, hold or alter a patients' individual medications at every transition point of care. Failure to reconcile medications can result in omissions, duplications, wrong dosages and medication interactions. Currently in Ireland there is no standardised process for Med Rec. Successful Med Rec is time consuming and is associated with a cognitive burden on clinicians that could potentially be relieved by technology. Consideration of an e-Med Rec solution can be considered an arduous task as it requires; consideration of the clinical workflow and culture of the organisation, effective communication and teamwork and a complex clinical process to be translated into a linear technological specification. In this research, a literature review was conducted, and semi-structured interviews were performed with key stakeholders to elicit their expert opinions on what an ideal e-Med Rec tool for an Irish setting would require. While tools to facilitate e-Med Rec have been implemented in some healthcare facilities with varying degrees of success, there is scant literature on the evaluation of such systems. For e-Med Rec to be fully adopted, it needs to be endorsed and incorporated both locally and nationally. At an institutional level it was found that endorsement by quality improvement leaders, highly integrated care, experience of technology and a culture of promoting patient safety could enhance the adoption of e-Med Rec tools. Persuading frontline users and improving awareness of the importance of Med Rec among clinicians has been seen to be essential for success. Workflow redesign was recommended as one of the main measures to increase compliance with the process. There is a desire for a standardised and simple solution for e-Med Rec. Development and refining of such a tool is an iterative process. It should ideally fit in with existing systems, be designed to allow for future integration and be compatible with enablers such as the National Medicinal Product Catalogue and individual Health Identifier (IHI) when it becomes available. The success of this project requires support from clinical leaders and government bodies. Work around the standardisation and agreement on a universally acceptable design should start now.

## Table of Contents

Declaration .....	ii
Permission to lend and/or copy .....	iii
Acknowledgements .....	iv
Summary.....	vi
List of Tables .....	x
List of Figures .....	xi
Abbreviations.....	xii
Glossary .....	xiii
Chapter 1. Introduction .....	1
1.1. Background and motivation .....	1
1.2. Research aims and objectives .....	3
1.3. Overview of the research .....	4
1.4. Overview of the dissertation .....	4
Chapter 2. Literature Review part I.....	6
2.1. Introduction .....	6
2.2. Method .....	6
2.3. Medication Management.....	8
2.4. Medication Reconciliation (Med Rec) .....	9
2.4.1. Introduction .....	9
2.4.2. The Medication Reconciliation (Med Rec) process .....	9
2.4.3. Medication Reconciliation (Med Rec) state-of-the-art.....	12
2.5. Electronic Medication Reconciliation (e-Med Rec) .....	14
2.5.1. Advantages of Electronic Medication Reconciliation .....	16
2.5.2. Barriers to Medication Reconciliation (Med Rec).....	17
2.6. Developing an Electronic Medication Reconciliation prototype .....	19
2.7. Core Functionality required for Electronic Medication Reconciliation.....	21
2.7.1. Computerized-physician-order-entry (CPOE) and Med Rec .....	22
2.7.2. Clinical Decision Support (CDS) .....	23
2.7.3. Accessing sources of ambulatory medicines information .....	25
2.7.4. Presentation of information from ambulatory medication lists.....	27
2.7.5. Presentation of information in an e-Med Rec tool.....	28
2.8. Workflow integration.....	29
2.8.1. Accessibility and editing rights .....	30
2.8.2. Use of system alerts and mandatory functionality.....	30
2.8.3. Patient engagement with the e-Med Rec process.....	33

2.8.4.	Usability testing and evaluation .....	34
2.9.	Conclusion.....	35
Chapter 3.	Literature review part II .....	36
3.1.	Introduction .....	36
3.2.	eHealth Ireland .....	36
3.3.	International eHealth .....	38
3.4.	Paper to Med Rec implementation Toolkit .....	40
3.5.	Implementation strategy .....	42
3.6.	Enablers for Integrated eHealth initiatives .....	43
3.6.1.	Individual Health Identifier.....	43
3.6.2.	Integrated Medication Records.....	44
3.6.3.	Interoperability .....	44
3.6.4.	National Medicinal Product Catalogue.....	46
3.6.5.	Audit.....	47
3.7.	Conclusion.....	48
Chapter 4.	Study Design and Methodology .....	49
4.1.	Introduction .....	49
4.2.	Rationale of research question .....	49
4.3.	Research Aim .....	49
4.4.	Research Objectives .....	50
4.5.	Research Design and Strategy.....	50
4.6.	Research Methods .....	53
4.6.1.	Introduction .....	53
4.6.2.	Clarification of Med Rec and BPMH .....	55
4.6.3.	Development of Topic Guide.....	55
4.6.4.	Development of Interview Prompt .....	56
4.6.4.	Semi-structured Interviews .....	56
4.6.5.	Synthesis of research output.....	58
4.7.	Ethical considerations .....	60
4.8.	Conclusion.....	60
Chapter 5.	Results and Analysis .....	61
5.1.	Introduction .....	61
5.2.	Results.....	62
5.2.1.	The Challenge.....	62
5.2.2.	Benefits .....	63
5.2.3.	Functionality.....	63



5.2.4. Workflow fit .....	67
5.2.5. Enablers .....	68
5.2.6. Strategy .....	72
5.4. Conclusion .....	74
Chapter 6. Evaluation, Discussion and Conclusion .....	75
6.1. Introduction .....	75
6.2. Proposed Gold Standard list of functionality requirements for an e-Med Rec tool. ....	75
6.3. Proposed classification of electronic Med Rec Systems .....	78
6.4. Discussion .....	81
6.5. Strengths and limitations of the study. ....	84
6.6. Future work and research .....	85
6.7. Conclusion .....	86
References .....	87
Appendices .....	95
Appendix A: Admission Medication Reconciliation Process (World Health Organisation, 2007). ...	95
Appendix B: Discharge Medication Reconciliation Process (World Health Organisation, 2007). ....	96
Appendix C: Example of Paper-Based Admission Medication Reconciliation Form. ....	97
Appendix D: Naas General Hospital Discharge Prescription Pilot Sample. ....	98
Appendix E: Stages of HIMSS Analytics EMR Adoption Model (EMRAM)(Himss and Emram, 2017). .....	100
Appendix F: Table Summary of Literature.....	101
Appendix G: Interview Topic Guide.....	102
Appendix H: Interview functionality prompt. ....	103
Appendix I: Letter of Invitation. ....	105
Appendix J: Participant Information Sheet. ....	106
Appendix K: Informed Consent form for Participant.....	107
Appendix L: Trinity College Dublin, Ethics Approval Confirmation.....	109

## List of Tables

Table 1. Details pertaining to the databases and search terms used for the literature review .....	7
Table 2. Advantages associated with electronic medication reconciliation. Excerpt from Canadian e-Med Rec implementation Toolkit (ISMP Canada and Canadian Patient Safety Institute, 2017). .....	17
Table 3. Adapted from the 'European Hospital Survey – Benchmarking Deployment of eHealth Services (2012-1013)' (Sabes-Figuera, 2013). .....	39
Table 4. Strategy for the implementation of a quality improvement program to optimize Med Rec (White <i>et al.</i> , 2011). .....	43
Table 5. Key informant analysis .....	57
Table 6. Themes and subthemes identified from interviews. ....	61
Table 7. Proposed Gold Standard e-Med Rec list of functionality requirements. ....	76
Table 8. Explanation of Different Levels of Classification of e-Med Rec solutions .....	80
Table 9. Implications of study for key stakeholders in the Irish setting as proposed by the author ...	83

## List of Figures

Figure 1. Strategies to prevent Adverse Drug Events at selected stages of medication management( <i>Medication Errors   AHRQ Patient Safety Network, 2015</i> ). .....	8
Figure 2. The proactive Med Rec process on admission (World Health Organisation, 2007).....	10
Figure 3. The retrospective Med Rec process on admission (World Health Organisation, 2007). .....	11
Figure 4. The discharge Med Rec process. Adapted from the North Carolina Center For Hospital Quality and Patient Safety (2006). .....	12
Figure 5. Continuum from paper based to fully electronic Med Rec(ISMP Canada and Canadian Patient Safety Institute, 2017). .....	14
Figure 6. Idealized overview of e-Med Rec(ISMP Canada and Canadian Patient Safety Institute, 2017). .....	15
Figure 7. CDS Functional Design for Med Rec (Berner, 2009). .....	24
Figure 8. Concept of comparison of lists to facilitate e-Med Rec.....	26
Figure 9. Reminder Alert Logic to improve physician compliance with the e-med rec process .....	31
Figure 10. SMARTSync reconciliation architecture (Ziminski <i>et al.</i> , 2012). .....	33
Figure 11. HIMSS Analytics' Electronic Medical Record Adoption Model ( <i>EMRAM   HIMSS UK</i> ). .....	40
Figure 12. Relationship between interoperability, Electronic Health Information Exchange and Med Rec. Adapted from (Elysee, Herrin and Horwitz, 2017).....	45
Figure 13. Blockchain Med Rec System Architecture (Ekblaw and Azaria, 2016).....	48
Figure 14. Methods used for the development of Ireland's eHealth strategy (Health Service Executive, 2013).....	51
Figure 15. Design-Science Research Guidelines (Hevner <i>et al.</i> , 2004).....	53
Figure 16. Overview of research process .....	54
Figure 17. Methods for the development of a proposed gold standard list of functionality requirements for an e-Med Rec.....	58
Figure 18. Methods used for the development of proposed graded classification of e-Med Rec tools .....	59
Figure 19. Evidence used for synthesis of Gold Standard e-Med Rec prototype .....	75
Figure 20. Synthesis of research that resulted in the development of proposed graded classification of e-Med Rec tools.....	78
Figure 21. Proposed classification of e-Med Rec tools.....	79
Figure 22. Work commenced in the study (shown in blue) and some proposed future work (shown in red) as depicted by the genres of inquiry framework for design-science (Baskerville, Kaul and Storey, 2015).....	85

## Abbreviations

ADE	Adverse Drug Event
API	Application Program Interface
BPMH	Best Possible Medication History
CDS	Clinical Decision Support
CPOE	Computerized Provider Order Entry
eHealth	Electronic Health
EHR	Electronic Health Record
e-Med Rec	Electronic Medication Reconciliation
EMEDS	Enterprise Medication Decision Support Services
eMR	Electronic Medicines Reconciliation
EMR	Electronic Medical Record
EMRAM	Electronic Medical Record Adoption Model
EPR	Electronic Patient Record
GP	General Practitioner
HSE	Health Service Executive
HIMSS	Healthcare Information and Management Systems Science
HIQA	Health Information and Quality Authority
HTML	Hypertext Mark-up Language
IHI	Individual Health Identifier
IPPOSI	Irish Platform for Patient Organisations, Science and Industry
IOM	Institute of Medicine
ISMP Canada	Institute for Safe Medication Practices Canada
IT	Information Technology
JCAHO	Joint Commission on Accreditation of Healthcare Organisations
MAR	Medication Administration Record
Med Rec	Medication Reconciliation
MedLis	National Medical Laboratory Information System
NCHD	Non-Consultant-Hospital-Doctor
NDF-RT	National Drug File Reference Terminology
NICE	National Institute for Health and Care Excellence
NIMIS	National Integrated Medical Imaging System
OTC	Over-The-Counter
PCRS	Primary Care Reimbursement Scheme
PAML	Pre-admission Medication List
PHR	Personal Health Record
SMART	Sustainable Medical Applications, Reusable Technologies
SMR	Shared Medication Record
WDO	Work Domain Ontology
WHO	World Health Organisation

## Glossary

- Admission Medication Orders- Prescriber-recorded admission medication orders documented within 24hours of admission to a healthcare institution (ISMP Canada and Canadian Patient Safety Institute, 2017).
- Adverse Drug Event (ADE)- An injury from a medicine or lack of an intended medicine. It includes adverse drug reactions and harm from medication incidents (ISMP Canada and Canadian Patient Safety Institute, 2017).
- Best Possible Medication History (BPMH)- A history created using a systematic process of interviewing the patient or carer, and a review of at least one other reliable source of medication information to obtain and verify all a patient's medication use (both prescription and non-prescription medication). Complete documentation includes drug name, dose, route and frequency of administration. The BPMH is more comprehensive than a routine primary medication history which may not have used multiple sources of information (ISMP Canada and Canadian Patient Safety Institute, 2017).
- Computerized Provider Order Entry (CPOE)- A health IT tool that facilitates the process of electronic order entry. CPOE allows for authorized healthcare personnel to order medications, tests and procedures and provide other instructions pertaining to the treatment of patients under their care (ISMP Canada and Canadian Patient Safety Institute, 2017).
- Discharge- The discontinuation of service by an institution.
- Discrepancy- A difference identified between the medication a patient is actually taking versus the information obtained from other sources (ISMP Canada and Canadian Patient Safety Institute, 2017).
- Electronic Health Record (EHR) refers to a system that makes up the secure and private lifetime record of a person's health and health care history. These systems store and share such information as lab results, medication profiles, key clinical reports (e.g. hospital discharge summaries), diagnostic images and immunization history. The

information is available to authorized healthcare providers (ISMP Canada and Canadian Patient Safety Institute, 2017).

- Electronic Medicine Reconciliation (e-Med Rec) system is an electronic system used in secondary care that ensures a patient's medication information is up-to-date and therefore accurate on admission, transfer and discharge (*Health Quality & Safety Commission | Electronic Medicines Management, 2017*).
- Electronic Patient Record (EPR) is a system used by a healthcare professional to store and manage patient health information and data, and include functionalities that directly support the care delivery process (Hyppönen *et al.*, 2016).
- Electronic prescribing (e-prescribing) is the utilisation of electronic systems to facilitate and enhance the communication of a prescription or medicine order.
- Health Information Exchange is the ability to exchange patient information across unaffiliated systems across different healthcare settings.
- Medication error can be defined as 'a failure in the treatment process that leads to, or has the potential to lead to harm to the patient' (Aronson, 2009).
- Medication management describes the delivery of patient-centred care to optimize safe, effective and appropriate drug therapy (ISMP Canada and Canadian Patient Safety Institute, 2017).
- Medication reconciliation (Med Rec) is a three-step process. It involves *verification* of the most up-to-date list of medications for a patient. *Clarification* to ensure all the medications and doses are appropriate. Finally, *reconciliation* occurs when this list is then compared to the current medication orders. Any decisions made around intentional changes to the current medication list are documented for the benefit of the next healthcare provider (*Institute for Healthcare Improvement: Accuracy at Every Step: The Challenge of Medication Reconciliation, 2018*).
- Patient safety as defined by the Institute of Medicine (IOM) is the 'prevention of harm to patients' (Mitchell, 2008).
- Personal Health (PHR) is a complete and partial health record under the custodianship of a person that holds all, or a portion of the relevant health information about that person over their lifetime. This is also a person-centric health record, unlike the EHR, the patient has control or 'custodianship' over the record, rather than the health care

provider. This record may be maintained using electronic tools such as consumer apps or web based resources (ISMP Canada and Canadian Patient Safety Institute, 2017).

- Prescribed medications are medicines that are prescribed by a healthcare practitioner. These medications include all prescription medication, may include over-the-counter (OTC) medication and vitamins (ISMP Canada and Canadian Patient Safety Institute, 2017).
- Risk Assessment involves the identification of risks, agreeing improvement programs to treat risks and ongoing evaluation and monitoring to treat risks (*Risk assessment - HSE.ie*, 2017).
- Senior leadership encompass people in leadership roles in an organisation that can remove obstacles and allocate resources (ISMP Canada and Canadian Patient Safety Institute, 2017).
- Transfer- An interface where orders need to be reviewed and rewritten according to facility policy. These may include; change of service, change of ward, post-operatively, change of institution of care (ISMP Canada and Canadian Patient Safety Institute, 2017).

## Chapter 1. Introduction

*“Assuming each preferred practice is a good practice, it matters less which process is selected as the basis for standardisation, it is the standardisation that matters most”* (World Health Organisation, 2007).

### 1.1. Background and motivation

The seminal ‘Institute of Medicine’ (IOM) report (2000) highlighted medication error as widely prevalent, costly and contributing to preventable causes of patient harm. There is a risk of medication errors occurring when a patient is transitioning through different care locations. It has been estimated that “50% of medication error and 20% of adverse drug events (ADE’s) occur due to poor communication at these points of transfer” i.e. admission, transfer and discharge of patients (Redmond *et al*, 2013).

Medication Reconciliation (Med Rec) involves the process whereby a complete and accurate list of a patient’s medication is discerned. It occurs when a patient is at a healthcare transition e.g. moving between primary and secondary care. It involves accounting for every medication a patient is taking, and documenting decisions made by a physician to actively discontinue, continue, hold or alter a patients’ individual medications at every transition point of care. It is essential to ensure these decisions and resulting medication list have been communicated appropriately to the next healthcare provider. Med Rec has been incorporated into the World Health Organisation’s (WHO) High 5 project which aims to examine the standardisation of clinical processes through the implementation of targeted patient safety strategies (World Health Organisation, 2014). The Health Information and Quality Authority (HIQA) has endorsed Med Rec as a national patient safety initiative for Ireland.

Med Rec is a patient safety initiative endorsed by multiple international establishments. However, healthcare institutions are struggling to develop sufficient tools and effective implementation strategies. Of the ‘patient safety goals’ established by the Joint Commission in the United States, Med Rec has been viewed as one of the most complicated ones. The Joint Commission on Accreditation of Healthcare Organisations (JCAHO), a national accreditation organisation in the United States, has encouraged institutions to standardise



their processes, keeping them simple in order to enable them to be easily incorporated into routine practice (Anderson, 2007). There is variability in the guidance of Med Rec definitions and hence there is a variability in Med Rec practices. There is no current national standardised approach to this process in Ireland.

Electronic medication management systems can support prescribing, ordering, dispensing and recording the administration of medication. Some international health organisations who have adopted electronic medication management systems, have considered the addition of an electronic Med Rec (e-Med Rec) tool to enhance patient safety. The WHO defines Med Rec as the formal process where “healthcare professionals partner with patients to ensure accurate and complete medication information transfer at interfaces of care” (World Health Organisation, 2007). From the existing literature which examines e-Med Rec systems, the advantages that Information Technology (IT) based solutions have over paper-based models are described and will be presented later in the dissertation.

Some Irish hospitals are working on technology solutions for local Electronic Patient Records (EPR's). eHealth Ireland are working on a national e-prescribing solution. However, this is not a full national medication management solution which incorporates Med Rec. Jonathan D Hron *et al.*, (2015) identified that it is possible to have a fully functioning EPR complete with e-prescribing and documentation systems yet a suboptimal Med Rec process. An e-Med Rec implementation toolkit has been developed in Canada which enables institutions to systematically address the inclusion of such a tool into their healthcare facilities. The incorporation of a Med Rec element of electronic medication management and prescribing systems is an important consideration while the development and implementation of such systems on a national scale is in its infancy. Inclusion of an electronic tool that facilitates Med Rec into existing and future prescribing systems could ensure that this recognised patient safety goal is not overlooked.

## 1.2. Research aims and objectives

“Towards a prototype and strategy for an electronic medication reconciliation capture in e-medication management systems in an Irish acute care setting”

To work towards addressing this research goal, the following will be developed through this study;

- An evidence-based, user-informed ‘gold-standard’ list of functional requirements for an e-Med Rec tool for use in electronic medication management systems in an Irish acute healthcare setting.
- A proposed graded classification of e-Med Rec tools.
- Development of key elements of a proposed strategy for the promotion of e-Med Rec on the Irish Health Agenda.

The research objectives are as follows;

- ❖ To review the relevant literature and identify the lessons learned regarding the functionality that is necessary for e-Med Rec tools.
- ❖ To review the relevant literature to see what the essential enablers for eHealth solutions in Ireland are.
- ❖ To interview key informants to ascertain their opinions on the functionality that is required for an e-Med Rec tool.
- ❖ To develop a proposed classification of the functionality of an e-Med Rec tool desired by end users and key informants.
- ❖ To explore how an e-Med Rec tool could fit into the workflow in the Irish healthcare setting.
- ❖ To propose a strategy for prioritizing e-Med Rec in the Irish healthcare setting based on international experience and the opinions and guidance of key informants.

### 1.3. Overview of the research

This study includes a review of the literature pertaining to the topics covered in this study. Electronic systems to support the activity around Med Rec and e-prescribing as well as current deficiencies in the Irish health IT infrastructure are the main topics of relevance. Government reports and policy documents also inform the content of the literature review and contribute to a domain analysis for the Irish health setting. The literature was used to identify research gaps and guide the research question. Research was performed using semi-structured interviews as the qualitative investigational tool. Results from the interviews were assessed in tandem with the findings from the literature and were combined to formulate recommendations for an e-Med Rec prototype, graded classification of e-Med Rec tools and strategy tailored for an Irish setting. A design-science conceptual framework was employed for this research.

### 1.4. Overview of the dissertation

Chapter 1 contains a brief introduction to the topic which will be covered in this dissertation. The background and motivation for the research question is discussed as well as the aims and objectives of this study. An overview of the research undertaken is described and the content of each chapter of the dissertation is summarised.

Chapter 2 contains part one of the literature review. The literature review is divided into two parts. This review will firstly present information from the literature regarding key aspects relating to an e-Med Rec functionality and workflow integration.

Chapter 3 contains part two of the literature review. Contained in this section is an overview of the e-Med Rec Implementation Toolkit as outlined by ISMP Canada the Canadian Patient Safety Initiative. The eHealth Ireland strategy will be introduced, and international eHealth experience will be explored. Identified enablers to e-Med Rec in an Irish setting will also be presented.

Chapter 4 outlines the study methodology and research design. This chapter revisits the research question and objectives. Details of the study such as the interview cohort and ethical considerations will be presented.

Chapter 5 presents the results of the qualitative research. The main emerging themes from the semi-structured interviews will be presented.

Chapter 6 contains the evaluation and discussion of the results of the research. The discussion will address the research question and offer some implications for the Irish Healthcare setting from the findings of the research. Proposed future work will also be presented. This chapter concludes the study.

## Chapter 2. Literature Review part I

### 2.1. Introduction

A review of the literature was undertaken in relation to electronic tools to facilitate Med Rec. Med Rec as a process and patient safety initiative are also reviewed. The method used to search the literature will also be presented. This review was performed to assess existing research in this area, identify research gaps, provide a rationale for further research and to guide the development of the research questions. This chapter will present part I of the results of the literature review.

### 2.2. Method

The literature was reviewed around the topics relating to e-Med Rec. Databases such as PubMed, Scopus and Web of Science were used to search for academic papers pertaining to the area of e-Med Rec and electronic medication management. Search terms of the relevant literature such as 'medication reconciliation', 'prototype', and 'medication error' were searched. Keywords and combinations were used. Cross references from key papers were followed up and included. Table 1 outlines a detailed search strategy of the literature.

Google and google scholar were also used to generate a more thorough search. Other terms relevant to the broader topic area were searched (eHealth, health informatics, medical informatics). Internet searches presented several editorials which were reviewed for relevance. Literature not identified through electronic searches such as national and international government and regulatory body reports were reviewed for relevance. Policy documents were investigated if relevant and commercial websites associated with e-Med Rec pilots and tools were explored.

A variety of databases were used as Health Informatics as a subject is in its infancy and the search terms in different databases retrieved a variety of material. There is a diversity of terminology used in Health Informatics and this is evident through the necessity to use a variety of search terms three different databases.

Table 1. Details pertaining to the databases and search terms used for the literature review

Database	Search Terms	Limits	Results
PubMed	(electronic) AND "medication reconciliation"	Language: English, Dates: Last 10 years, Species: Human	246
	("electronic prescribing") AND "medication reconciliation"	Language: English, Dates: Last 10 years, Species: Human	19
	("Medication Reconciliation") OR Medication error	Language: English, Dates: Last 10 years, Species: Human	1505
	((("electronic prescribing") OR "e-prescribing") OR "electronic ordering"	Language: English, Dates: Last 10 years, Species: Human	812
	(((((("electronic prescribing") OR "e-prescribing") OR "electronic ordering"))) AND (((accreditation) OR classification) OR standardization) OR standards)) AND (("medication reconciliation") OR "medication error")	Language: English, Dates: Last 10 years, Species: Human	20
	((medication reconciliation) AND electronic) AND medication management	Language: English, Dates: Last 10 years, Species: Human	236
	((electronic) AND "medication reconciliation") AND development	Language: English, Dates: Last 10 years, Species: Human	30
	((electronic) AND "medication reconciliation") AND classification	Language: English, Dates: Last 10 years, Species: Human	10
Web of Science	electronic AND "medication reconciliation"	Dates: 2000-2018	192
	electronic AND "medication reconciliation" AND accreditation	Dates: 2000- 2018	3
	electronic AND "medication reconciliation" AND prototype	Dates: 2000- 2018	2
	electronic AND "medication reconciliation" AND application	Dates: 2000- 2018	16
Scopus	electronic AND "medication reconciliation"	Dates: 2000- present day	369
	electronic AND "medication reconciliation" AND application	Dates: 2000- present day	36

### 2.3. Medication Management

Medication management in healthcare is a complex process. It requires effective communication across healthcare settings and between healthcare providers, the patient and their families. Some of the areas medication management encompasses are the supply, prescribing, dispensing, administration and review of medication. It is a complex and multifaceted operation involving multiple people and many steps. Figure 1. outlines some of the steps involved and proposed safety strategies associated with each. Some of the safety strategies outlined could involve IT systems which can assist at each of the stages of medication management. Med Rec is included here as recognised safety strategy associated with the prescribing stage.

STAGE	SAFETY STRATEGY
Prescribing	<ul style="list-style-type: none"> <li>• Avoid unnecessary medications by adhering to <a href="#">conservative prescribing</a> principles</li> <li>• <a href="#">Computerized provider order entry</a>, especially when paired with <a href="#">clinical decision support systems</a></li> <li>• <a href="#">Medication reconciliation</a> at times of transitions in care</li> </ul>
Transcribing	<ul style="list-style-type: none"> <li>• <a href="#">Computerized provider order entry</a> to eliminate handwriting errors</li> </ul>
Dispensing	<ul style="list-style-type: none"> <li>• <a href="#">Clinical pharmacists</a> to oversee medication dispensing process</li> <li>• Use of "tall man" lettering and other strategies to minimize confusion between look-alike, sound-alike medications</li> </ul>
Administration	<ul style="list-style-type: none"> <li>• Adherence to the "<a href="#">Five Rights</a>" of medication safety (administering the Right Medication, in the Right Dose, at the Right Time, by the Right Route, to the Right Patient)</li> <li>• <a href="#">Barcode medication administration</a> to ensure medications are given to the correct patient</li> <li>• <a href="#">Minimize interruptions</a> to allow nurses to administer medications safely</li> <li>• <a href="#">Smart infusion pumps</a> for intravenous infusions</li> <li>• <a href="#">Patient education</a> and revised <a href="#">medication labels</a> to improve patient comprehension of administration instructions</li> </ul>

Figure 1. Strategies to prevent Adverse Drug Events at selected stages of medication management(*Medication Errors | AHRQ Patient Safety Network, 2015*).

## 2.4. Medication Reconciliation (Med Rec)

### 2.4.1. Introduction

There is much evidence to support the practice of Med Rec and its contribution to improved patient safety. Several organizations worldwide have supported the practice of Med Rec including; the World Health Organisation (WHO), the Joint Commission in the United States of America, the National Institute for Health and Care Excellence (NICE) and the National Patient Safety Agency in the United Kingdom (Monkman *et al.*, 2013). Med Rec has been incorporated into the WHO's High 5 project due to its recognised contribution to preventing medication related harm (World Health Organisation, 2007). On a national level, the Health Information and Quality Authority (HIQA) has endorsed the importance of the Med Rec process as a patient safety initiative.

### 2.4.2. The Medication Reconciliation (Med Rec) process

Med Rec can contribute to patient safety at care transitions (Almanasreh, Moles and Chen, 2016). Firstly, it involves the process whereby a complete and accurate list of a patient's medication is discerned. This can be obtained from multiple sources i.e. patient themselves, community pharmacy, General Practitioner (GP) practice, a relative or carer. At least two diverse sources ideally one source being the patient themselves, are used to obtain a gold-standard pre-admission medication list (PAML). This can be thought of as the best possible medication history (BPMH). Complete Med Rec incorporates reconciling the medicines which involves accounting for every medication a patient is taking, and recording decisions made to actively continue, discontinue, hold or alter a patients' individual medications at every transition point of care. These actions should be documented, and it is essential to ensure these details have been appropriately communicated to the next healthcare provider.

Errors in the transmission of accurate medication lists can result in discrepancies such as medication commission or omission and errors in frequency or dose. Errors have been linked to higher re-hospitalisation rates and potential ADE's. An incorrect medication history can lead to uninformed and potentially incorrect clinical decisions. To summarize, a three-step process for Med Rec can be outlined as (ISMP Canada and Canadian Patient Safety Institute, 2017);



1. **Creation of the BPMH** which outlines the medication name, dose, route and frequency. This comprises of interviewing patients or carers and reviewing at least one other reliable source of information.
2. **Reconciliation of medicines** which uses the BPMH to either create admission orders or compare against admission, transfer or discharge medication orders, and identify and resolve all differences or discrepancies.
3. **Documentation and Communication** of any resulting changes in medication orders to patients/carers and the next healthcare provider.

Med Rec can be proactive or retroactive. Figure 2 depicts the proactive process of admission Med Rec. This is the process which is ideally completed by the attending physician. This may be completed when there is access to accurate pre-admission medication sources and ideally may be confirmed by either the patient themselves or the person who is responsible for managing the medications in the home setting. This results in the admitting medication list equating to the BPMH. This may happen in a variety of clinical settings both in primary and secondary care.

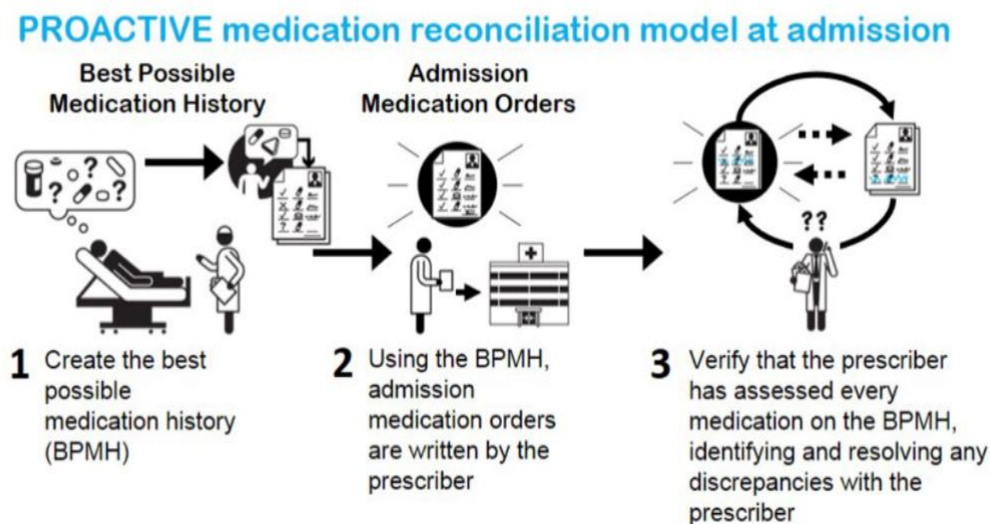


Figure 2. The proactive Med Rec process on admission (World Health Organisation, 2007).

Retroactive Med Rec also takes place, more commonly in the in-patient hospital setting where a patient may be admitted unexpectedly to hospital in an emergency. In this case, a medication list may be compiled by the attending physician, but it may not be possible

to have timely access to the most recent medication list or to verify an accurate BPMH. Med Rec may often be completed in retrospect at the earliest opportunity. This can often be hours after the admission or even the next day. Figure 3 represents the retrospective process of Med Rec. This in theory may be performed by nurses, physicians or pharmacists. Although published data suggests that pharmacists perform better at taking medication histories than most physicians or nursing staff (Sardaneh *et al.*, 2017). Appendix A depicts the stages involved in the Med Rec process on admission in more detail.

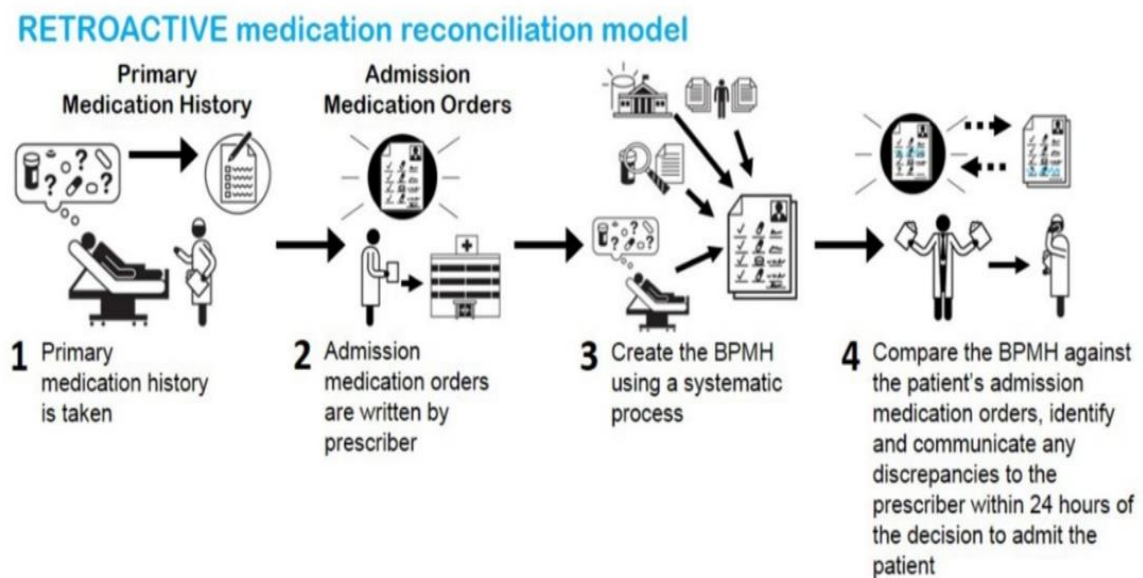


Figure 3. The retrospective Med Rec process on admission (World Health Organisation, 2007).

Figure 4 illustrates the Med Rec process at discharge. Med Rec at this stage should use information from the BPMH history on admission for comparison with the current medication administration record. Ideally, there is a comparison between these two medication lists and documentation and communication of any intentional changes for the next healthcare provider are the steps involved in a complete Med Rec process at this point. Appendix B depicts the stages involved in the Med Rec process on discharge from a secondary care setting in more detail.

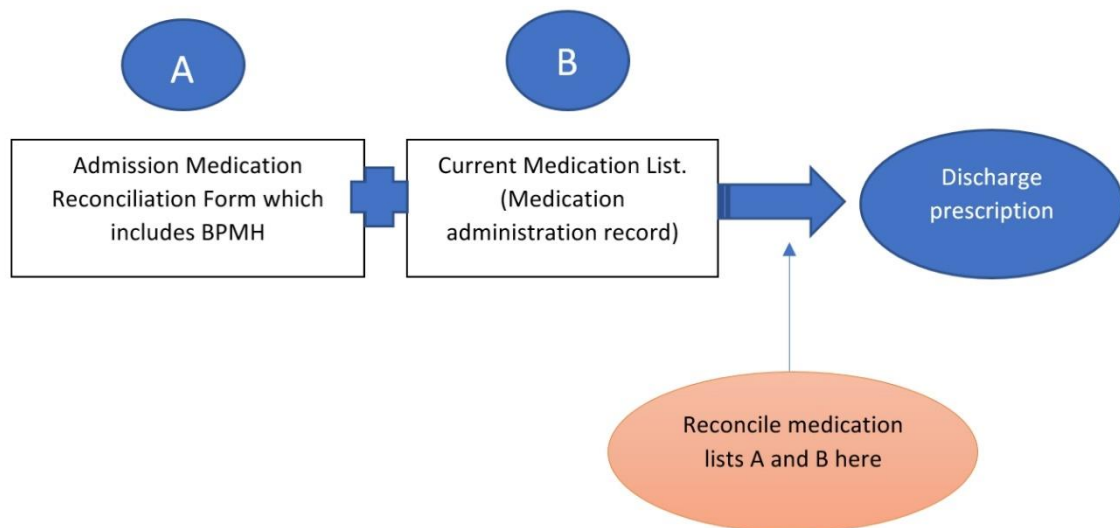


Figure 4. The discharge Med Rec process. Adapted from the North Carolina Center For Hospital Quality and Patient Safety (2006).

#### 2.4.3. Medication Reconciliation (Med Rec) state-of-the-art

In 2010 the Health Service Executive (HSE) ‘Report of the National Acute Medicine Program’ mandates that Med Rec should occur immediately or as soon as possible after a patient’s arrival to hospital (AMP Working Group, 2010). Med Rec as part of a pharmacist-led service is ideally completed with 24 hours of admission or 72 hours after a weekend admission. Pharmacy opening hours (typically Monday to Friday) can delay the performance of Med Rec for patients admitted at weekends. Clinical practice suggests targeting completion of the Med Rec process towards those groups who are most at risk of experiencing a medication related adverse event. These groups may include; those aged over 65 years, those on 5 or more medications and those taking high-risk medication.

There is variability in the guidance of Med Rec definitions and hence there is a variability in Med Rec practices. The WHO and the Joint Commission have different definitions. When attempting to define Med Rec for the purpose of building an electronic

solution, Poon *et al.*, (2006) found the lines of responsibility among the clinical disciplines not to be very clear and that 'best practice' remains to be absolutely defined.

There are a variety of Med Rec collection tools in use in different institutions. Most are paper-based collection forms and some institutions have a paper-electronic hybrid solution. Appendix C provides an example of a paper-based collection tool used in one acute hospital in Ireland. Current practice varies between hospitals in Ireland. Some hospitals prioritise Med Rec and have a formal process whereby Med Rec at transfers of care is performed for a selected cohort of patients. Between 2016 and 2017, HIQA inspected 34 public acute hospitals as part of its medication safety monitoring programme. The figures show that 13 out of 34 acute hospitals in Ireland deliver a pharmacy-led admission Med Rec service and Med Rec on both admission and discharge is being practiced in only three out of 34 hospitals in Ireland (Health Information and Quality Authority, 2018b). Appendix D displays an example of a discharge prescription where discharge Med Rec has been performed. A communication box outlines the changes in medication to the next healthcare provider fulfilling HIQA's national standards for patient discharge summary information (Health Information and Quality Authority, 2013).

Managing medication across the care interfaces requires collaboration and cooperation. The BPMH is the foundation of the Med Rec process. The complexity in this process arises as obtaining the most accurate list of what a patient is taking can be difficult as often the list provided may not be up-to-date or a patient's family members/carers may not have the complete information required. There is currently no facility for physicians to access medication records from GP surgeries or community pharmacies in Ireland. This is another obstacle for timely acquisition of the most accurate PAML. The best model to implement the practice of Med Rec into a clinical workflow remains unclear.

Currently in Ireland there is no standardised process for Med Rec. However, the HSE 2018 service plan has outlined its desire to work towards improving quality and safety through the provision of care which is delivered 'according to the best evidence as to what is clinically effective in improving health outcomes' (Health Service Executive, 2018). The service plan also acknowledges the aim of the Irish Health Service to provide care is delivered at the same quality to all patients. This supports the case to move towards standardisation of the Med Rec process.

## 2.5. Electronic Medication Reconciliation (e-Med Rec)

One of the key recommendations from the 2018 HIQA Medication Safety Monitoring report was to develop a national approach to advance Med Rec by using electronic solutions to reduce time spent by clinical staff to complete this activity. (Health Information and Quality Authority, 2018b) It also recommended that at a national level hospital groups should work together to improve medication safety through the implementation of electronic solutions for Med Rec.

Electronic Med Rec (e-Med Rec) tools are tools that support the Med Rec process. Jonathan D. Hron *et al.*, (2015) proposed that an e-Med Rec system should consist of a sole source for medication review, one which prompts an action to be completed for all pre-admission medicines and a systematic approach to ensure this process is routinely performed. Consideration of an e-Med Rec solution can be considered an arduous task as it requires; consideration of the clinical workflow and culture of the organisation, effective communication and teamwork between a diverse group of clinicians, a multi-step process to be completed by a group of often independently working clinicians in a collaborative manner and a complex clinical process to be translated into a linear technological specification (Agrawal and Wu, 2009).

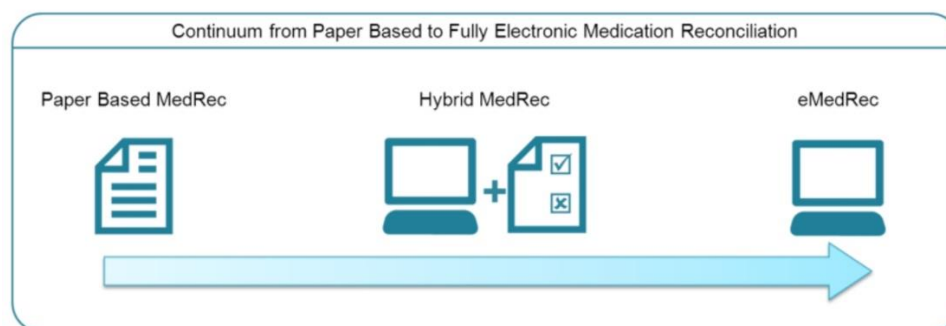


Figure 5. Continuum from paper based to fully electronic Med Rec (ISMP Canada and Canadian Patient Safety Institute, 2017).

Figure 5 outlines the continuum of e-Med Rec tools that exist. Paper-based collection forms are widely in use, some tools consist of a hybrid of a paper collection form followed by the input of data into a dedicated computer program and finally, fully functioning dedicated e-Med Rec tools. There is international experience in electronically enhancing the Med Rec

process. New Zealand, Australia, Denmark, Northern Ireland and the United States (US) have developed e-Med Rec facilities to complement their e-prescribing solutions. Figure 6. outlines all the components that may encompass an idealized e-Med Rec solution.

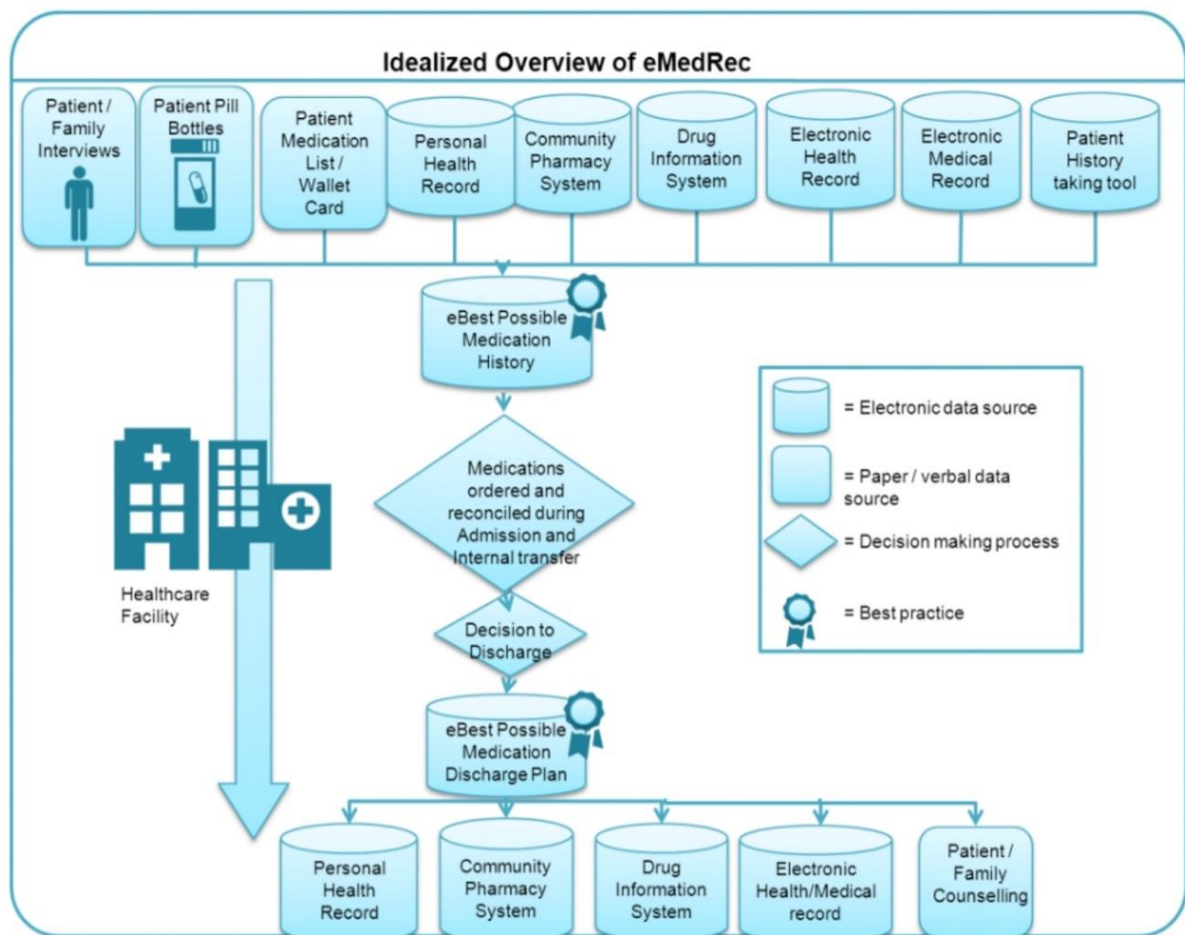


Figure 6. Idealized overview of e-Med Rec (ISMP Canada and Canadian Patient Safety Institute, 2017).

Considering an IT solution for Med Rec necessitates consideration of the process, work-flow and informatics challenges. Having a successful admission Med Rec tool could conversely benefit the discharge process. Communication around changes in medication regimens is essential and has been shown to be inconsistent at this point. While these tools have been implemented in some healthcare facilities there is scant literature on the evaluation of such systems.

Process standardisation can improve patient safety. The WHO High 5 report acknowledges that when it comes to safety, *standardisation* produces better results than the variance of 'best practices'. This report aims to standardise the Med Rec process in healthcare

organisations around the world. It also acknowledges that while the concept of Med Rec is simple, it has proved difficult to implement reliably (World Health Organisation, 2007). This report also highlights that effective implementation of Med Rec requires integration into current medication management and patient flow systems instead of creating new tasks. Automating the process could assist in standardising the documentation of medication lists and sharing this information across the continuum of care. However, the optimal design and implementation of an e-Med Rec system is currently not known (Turchin *et al.*, 2008).

#### 2.5.1. Advantages of Electronic Medication Reconciliation

Introduction of automated systems can mandate process' to be completed. Electronic solutions have been used to ensure compliance with the Med Rec process. Three hospitals in the US reported increased compliance rates with Med Rec when they moved from paper-based to an automated system. After the introduction of Computerised-Provider-Order entry (CPOE) it was observed that compliance rates increased from about 30% to over 75%. Another hospital saw discharge Med Rec compliance increase from 0% to 91% in the first month after implementation of an electronic solution (Anderson, 2007).

A study in the US examining the effects of an e-Med Rec system on ADE's highlighted the advantages that IT based solutions have over paper-based models. These include (Schnipper *et al.*, 2009);

- ❖ The capacity to utilize existing sources of patient's medicines information.
- ❖ Improved integration for hospitals which utilize CPOE.
- ❖ Sharing of information between healthcare providers.
- ❖ Automatic production of documentation for discharge documents.
- ❖ Comparison of different medication lists to facilitate reconciliation and patient education.
- ❖ Reminders and alerts to ensure compliance.
- ❖ The ability to track compliance for informing continued process improvement

Improved legibility and communication are among the advantages that using electronic solutions can assist with over paper-based processes. For Med Rec, technology can

improve standardisation, accessibility to information and it can support clinical activities through the assistance of clinical decision support (CDS). Table 2 summarizes some of the benefits as presented in the literature and evaluation measurements.

Table 2. Advantages associated with electronic medication reconciliation. Excerpt from Canadian e-Med Rec implementation Toolkit (ISMP Canada and Canadian Patient Safety Institute, 2017).

<b>Advantage</b>	<b>Evaluation</b>	<b>Reference</b>
Improved compliance with the process through use of alerts.	Process measure	(Agrawal and Wu, 2009)
Improved access to electronically available sources of pre-admission medication lists or ambulatory electronic medication records.	Process measure	(Mueller <i>et al.</i> , 2012)
Integration with CPOE to improve the medication ordering process.	Process measure	(Schnipper <i>et al.</i> , 2009)
Improved efficiency of medication related processes in healthcare organisations.	Process measure	(Poon <i>et al.</i> , 2006) (Sardaneh <i>et al.</i> , 2017)
Reduced unintended medication discrepancies on admission and discharge.	Outcome measure	(Jonathan D. Hron <i>et al.</i> , 2015)

### 2.5.2. Barriers to Medication Reconciliation (Med Rec)

It is important to acknowledge some of the barriers to Med Rec. In hospitals where the provision of a Med Rec service is primarily provided by pharmacists, the practice can be limited to pharmacy opening hours. The use of electronic systems is currently compromised due to interoperability challenges between different healthcare institutions and community pharmacy records. Med Rec is a matter of information organisation and the implementation can be dependent to a degree on the staff involved, systems of collection and communication of medicines information (World Health Organisation, 2007). Generally, studies have identified Med Rec as necessary but have not decided on a definitive solution to current issues. The variability of processes and tools currently in practice unfortunately doesn't make it easy to compare Med Rec solutions (Markowitz *et al.*, 2011).

Causes of errors are often related to miscommunication, documentation, transcription and teamwork (Paparella, 2006). There are numerous potential sources of



medication information and different healthcare professional groups (physicians, nurses and pharmacists) may approach the collation of this data differently using different tools and protocols. This uncoordinated set of activities can lead to unnecessary redundancy (where a patient can be interviewed multiple times regarding the medication they were taking at home) or a missed opportunity for collaboration (Poon *et al.*, 2006). Successful Med Rec is resource intensive and requires multi-disciplinary collaboration. It is time consuming and is associated with a cognitive burden on clinicians that could potentially be relieved by technology.

Although e-Med Rec has many benefits, the risks that are potentially introduced by the introduction of an electronic solution include (ISMP Canada and Canadian Patient Safety Institute, 2017):

- Over-reliance on electronic medicines lists and performance of/avoidance of poor quality interviews with patients/carers.
- Technology-induced errors.
- Workload being inadvertently increased by requiring electronic entry of medications.
- Changing the ways of communication amongst users.
- Resistance to adoption amongst healthcare professionals.
- Ineffective or inadequate education and training for end users.

Some medications such as insulin require variable dosing regimens which may cause difficulty when this is recorded electronically. A study undertaken in Denmark focused on the complex issue of the prescription of the variable dosing of warfarin and how the Shared Medical Record (SMR) can support the documentation of the fluctuating dose. Warfarin is an oral anticoagulant, which is a group of high-risk medicines. They are one of the most commonly implicated medication group in ADE's (Andreica and Grissinger, 2015). The findings of this study showed that the SMR introduced new errors around prescribing this medication, possibly compromising patient safety (Helene Tarp, Lili Worre Høpfner Jensen, Nikolaj Krabbe Jepsen, Henrik Majkjær Marquart, Mads Clausen, Nina Aagaard Madsen, 2017). While the SMR has solved the problems of accumulation, accessibility and reconciliation, other problems were found to be introduced. This study found that higher degree of

standardisation of the Med Rec and the SMR is required due to potential risk to patient safety around more complex prescriptions. Even with an SMR medication errors still occurred at the transitions of care due to the complexity of human factors. This highlights the need for an end user informed prototype, iterations and process standardisation.

The introduction of IT can introduce its own set of errors and challenges. The Hierarchy of Hazard Controls should be considered, and a risk assessment carried out about before any large-scale introduction on a e-Med Rec tool.

## 2.6. Developing an Electronic Medication Reconciliation prototype

A prototype is a draft version of an application that represents the range of the product. Prototypes can be high, medium, or low fidelity and range from fully functional to paper mock ups (Bassi, Lau and Bardal, 2010). Developing a prototype is important prior to full scale implementation of an application as it allows an opportunity to gain insight into the overall design. Prototype development can be an iterative process and the development of most prototypes to date have adopted plans to improve the tool and adapt it to the user's needs and to their workflow (Marien, Krug and Spinewine, 2017).

While Med Rec is internationally acknowledged as an important patient safety practice, there is no clear guidance for the design and development of e-Med Rec processes and tools. For example the National Institute for Standards and Technology defines Med Rec as the process of electronically comparing two or more medication lists for a single patient (The National Institute for Standards and Technology, 2010). While HIQA defines Med Rec as the process of "creating and maintaining the most accurate list possible of all medications a person is taking" (Health Information Quality Authority, 2014).

Med Rec is a complex process. An agreed electronic prototype has the potential to improve consistency and accuracy of this process. One study which developed a prototype for e-Med Rec hypothesized that a systematic user-interface design which was developed through the identification of the task requirements using a Work Domain Ontology (WDO), could improve the efficiency and quality of the Med Rec process (Markowitz *et al.*, 2011). A WDO outlines the basic task through separation from the work context, application technology systems or environmental factors.

The literature documented various experience in the development of e-Med Rec prototypes or tools. Yu, Leising and Turner, (2007) acknowledge that while there are numerous standalone e-Med Rec tools, few studies that demonstrate the success of these solutions and there is no consensus on how best to create an e-Med Rec tool. An academic paediatric hospital in the US developed an integrated Med Rec prototype using readily available service orientated technology. Key requirements for standardising the process were identified;

- ❖ Standardisation of the medication history intake.
- ❖ Avoidance of redundant data entry.
- ❖ Performance of Med Rec forms during transfers of care.
- ❖ Seamless integration into the physician and nursing workflow (+/-CPOE).

Another hospital which implemented e-Med Rec aimed to achieve these additional aims (Bails *et al.*, 2008);

- Have measurable compliance rates to facilitate ongoing feedback.
- Be a shared interdisciplinary activity.
- Have mandatory settings to ensure compliance.

Hamann *et al.*, (2005) identified the principal challenges in designing an e-Med Rec tool are as follows;

- Verification of medication.
- Decision regarding which medications to continue.
- Transformation of admission medication to ordering of medication.
- Tracking medication changes through the hospital stay through to discharge.
- Communication of reconciled medication lists to the next healthcare provider.
- Documentation of actions.
- Aggregation of data for quality and safety reports.

IT solutions under consideration include (Hamann *et al.*, 2005):

- Creation of a repository to store Med Rec instances over time.
- Collation of a broad data set to facilitate Med Rec.
- Possible integration of BPMH and CPOE.
- National Medicinal Product Catalogue.
- Clinical Decision Support (CDS) integrated in the e-Med Rec process.

Cadwallader *et al.*, (2013) designed an e-Med Rec application for an EPR that reflected the ‘visual organisation, categorization, modality of interactions and presentation of medication information from 3 various sources; patient, EPR and pharmacy.’ The four design considerations in the synthesis of this prototype were as follows;

1. Medication information from various sources.
2. Identification of changes to a patient’s medication regimen.
3. Medication sorting and display through alphabetization.
4. Heuristic user interface design for medication information display (system and real-world match, consistency and standards, flexibility and efficiency of use and minimalistic design).

## 2.7. Core Functionality required for Electronic Medication Reconciliation

The literature was reviewed for studies involving e-Med Rec, and the key functionality was analysed. Some papers compared the introduction of the new functionality to pre-existing paper-based processes. Most papers reviewed focused on one aspect of functionality which enabled a specific segment of the Med Rec process. A systematic review of Med Rec tools outlined that 5 out of 18 reports offered various possibilities for organizing medication lists differently and only 3 studies documented reasons for the cessation of a medication. Other functionalities reported in this review included methods of reducing cognitive burden such as viewing medication lists side by side and using filters to organise unreconciled medications. Additional functionality included gathering information from multiple sources, giving access to detailed information around prescribing, dispensing etc. Communicating the reconciled list to other healthcare providers in a timely manner, linking decision support systems (drug-drug interaction and decision to admit patients) and an automatic link to CPOE

were other functionalities reviewed (Marien, Krug and Spinewine, 2017). One study which implemented a successful Med Rec solution aimed to standardize and simplify the tool. It involved refining the application to include the following elements (White *et al.*, 2011);

- ❖ Separate functions and views for prescribers and nurses.
- ❖ Patient information interfaced with the hospital administration system.
- ❖ Auto-completion features for dose, frequency, route, time of last dose, individual fields with drop-down lists and a space for additional comments.
- ❖ Medication library.
- ❖ Basic reconciliation functions such as continue, discontinue and hold.
- ❖ Access to previous medication lists for repeat patient encounters

#### 2.7.1. Computerized-physician-order-entry (CPOE) and Med Rec

Computerized-physician order entry (CPOE) refers to a system which enables physicians to place orders electronically which are then transmitted directly to the recipient (Rose and Joshi, 2018). Many papers reviewed explored the possibility of combining CPOE with the Med Rec process.

Bails *et al.*, (2008) reported that at their study site, their online Med Rec process had a higher likelihood of success when the medication ordering facility was also online. This study concluded that in hospitals which have an EPR and CPOE it is preferable to have an e-Med Rec capture to complement these systems, as opposed to a paper-based one (Bails *et al.*, 2008).

One Med Rec tool in the US draws on a medication list from a patient's profile in the healthcare institution's EPR. The next step involves the action, where the prescriber selects one of the following options; 'continue, discontinue, substitute, unable to verify' (Agrawal, Wu and Khachewatsky, 2007). For ordering the compiled PAML is made available in real time to the prescriber when they are creating orders using CPOE screen. Finally, a pharmacist performs the reconciliation aspect. The pharmacist can view the CPOE orders and PAML which are displayed side by side using a split screen technique. This study concluded that to have an effective e-Med Rec tool, it must complement the CPOE process.

The most common error in medication-history taking, is omission of a medication that was taken at home. While CPOE systems with Clinical Decision Support (CDS) can address drug-drug interactions, dose range checking and therapeutic duplication they cannot detect unintentional omissions to PAML's. The CPOE system can only function with the information it has access to. An evaluation highlighted the 'safety-gap' when the medication ordering system (CPOE) and BPMH (e-Med Rec systems) are separate. The computerized systems showed a low rate of discrepancies between the BPMH and the medication orders (3.12%) when compared with the literature (54-57%). This evaluation promotes the concept of the integration of CPOE and e-Med Rec.

While CPOE is an important tool which may help in the prevention of medication errors, it's isolated use is not sufficient to prevent prescribing errors (Agrawal and Wu, 2009). Information in the literature on the unintended consequences of technology, indicated that there is a concern that over-automation of process' may bypass certain safety checks that are clinically necessary. Poole *et al.*, (2006) acknowledge this in relation to automatically creating orders from the Med Rec list. It is important to take into consideration that automatically converting the BPMH into admission orders may bypass certain CPOE safety mechanisms. So, while the concept of linking CPOE and Med Rec is seen to be desired by a proportion of end users it remains to be clearly defined how best they can complement each other in practice.

#### 2.7.2. Clinical Decision Support (CDS)

Clinical Decision Support (CDS) systems provide both healthcare providers with clinical knowledge and patient-related information which is intelligently filtered or presented at appropriate times to enhance the care of patients (Berner, 2009). The design of CDS systems intends to enhance healthcare processes and outcomes which can contribute to improved patient safety (Amit X. Garg *et al.*, 2005). They are designed to aid healthcare practitioners through incorporation into their work practice and facilitating tasks that require clinical knowledge and data interpretation (Coiera, 2003). Prescribing decision support systems can utilise several repositories of information such as, a medicines information source and guideline database, patient's medication history and patient specific details (Schiff GD and Rucker T, 1998). Decision support can support in the prescribing process and improve patient safety through consideration of patient specific parameters in pharmacotherapeutic

decisions, monitoring and documentation of ADE's, dosing calculations, interactions, and surveillance of therapy outcomes (Schiff GD and Rucker T, 1998).

An e-Med Rec tool can itself be viewed as a decision support tool as its purpose is to aid physicians in making more informed clinical decisions by having the most accurate and current medication details to work from. Some Med Rec prototypes have been seen to incorporate element of formal CDS functionality into their design.

One study in the US outlined the CDS functional design and system requirements for e-Med Rec. As detailed in figure 7, this includes the ability to identify medication optimization opportunities and the presentation of suggestions to the prescriber. Collaborative filtering has also been investigated as a tool for reconciling medication lists complementing the process driven systems which are currently recommended. Results showed that a medication omission was found approximately 40-50% of the time (Hasan *et al.*, 2011).

- **Communicate with the EMR system**
    - Query Patient Data
      - Admission Medication List
      - Active Medication List
    - Return Discharge Medication List
  - **Optimize Medication List**
    - Combine Medication Lists (Admission + Active)
    - Present info efficiently for Physician assessment
    - Identify additional optimization issues: therapeutic duplication, adverse reaction, therapeutic indication
  - **Interact with Discharging Physician (GUI)**
    - Present suggestions
    - Permit suggestion over-ride, select different decision criteria
    - Allow manual additions, changes, eliminations of medication at time of patient review
  - **Manage Knowledge Base (GUI)**
    - Maintain Medication Terminology – External Knowledge Sources
    - Maintain Inference Rules
  - **Consume System-Generated Performance Info**
    - Collect feedback to drive continuous improvement
- Model

Figure 7. CDS Functional Design for Med Rec (Berner, 2009).

It has been found that most potential ADE's occur with discharge medication orders (Pippins *et al.*, 2008). If the discharge medication regimen is poorly documented or

inaccurate, these errors may be propagated to subsequent healthcare encounters 'perpetuating the cycle of medication history errors, incorrect drug orders and ADE's' (Schnipper *et al.*, 2011). A study conducted by Schnipper *et al.*, (2011) involved developing a tool within the EPR that facilitates Med Rec after hospital discharge. This Med Rec tool used the services of Enterprise Medication Decision Support Services (EMEDS). The technique used, can compare two medication lists. It can sort medications using the EMEDS mapping and the 'First DataBank' classification and it can report on the differences or discrepancies. The PAML within the EPR can be compared to the hospital discharge medication list and the differences can be highlighted.

CDS has the potential to enhance Med Rec tools by incorporating artificial intelligence to compare medication lists, highlight discrepancies between lists and present suggestions to prescribers. This is quite an advanced feature and would possibly be later in the development stage of an e-Med Rec prototype.

### 2.7.3. Accessing sources of ambulatory medicines information

Med Rec involves compiling an accurate list of the patient's current medication regimen. This may be obtained from several sources. Some hospitals have an Electronic Patient Record (EPR) which may contain medication information for patients. Med Rec tools that have been implemented and piloted in such hospitals have been able to access this information and this has formed the basis for the subsequent verification by the patient of the BPMH.

Two sources of a patient's medication information are GP records and community pharmacy records. The GP records contain prescription information and the community pharmacy records provide information about what the patient received. Access to 'prescribed' and 'dispensed' data provides an invaluable insight into what the patient is prescribed as distinct from what the patient is collecting from their community pharmacy. Compliance issues can be immediately highlighted when these lists are juxtaposed.

Med Rec is still a manual process in most of Australia. eRx is one of Australia's electronic prescription exchange service. The original 'Medview' pilot demonstrated the capacity of web applications to draw on information to data which is captured in existing systems. The updated application: 'Medview Medicines Workspace' allows healthcare



professionals to view a combined list of patients' 'prescribed and dispensed medication' from the community, hospital and age-related care settings. The pilot found that through the sharing of this clinical data (with patient consent), there was improved medication management and increased patient safety. This proposed update to their original application will facilitate authorised healthcare providers to view both hospital data and pharmacy data at the same time. This data may be curated into a reconciled list which can then be verified by the patient (*Medview Medicines Workspace - Bridging the Gap*, 2016). This concept of reconciling pre-admission lists and creating the BPMH is depicted in figure 8.

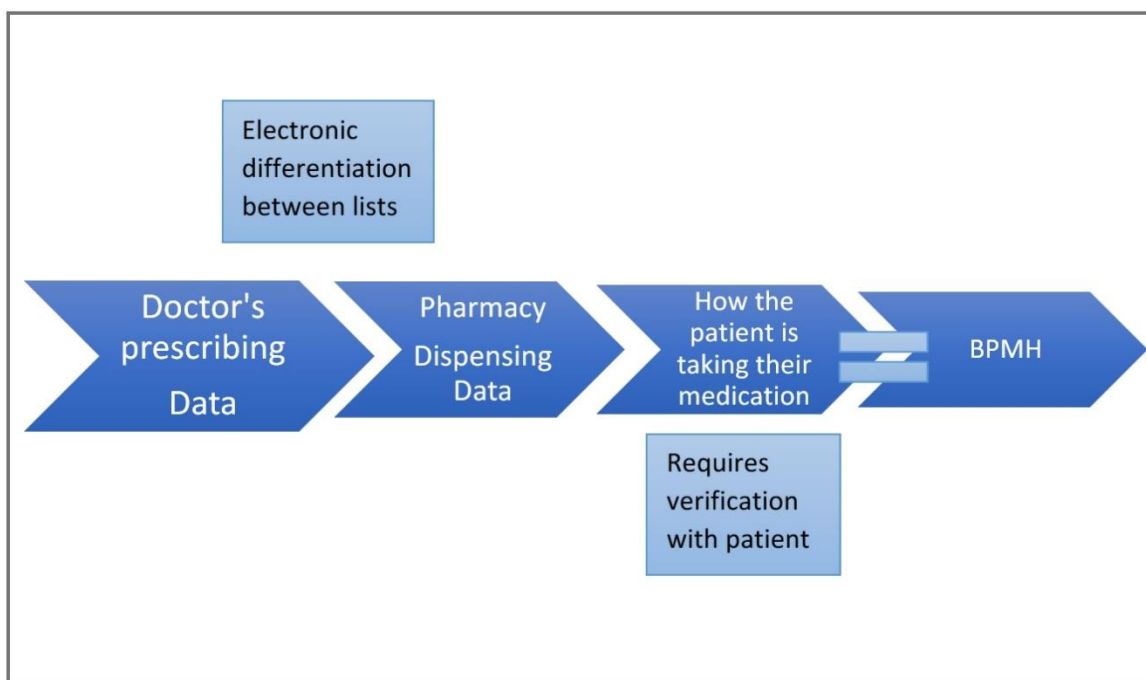


Figure 8. Concept of comparison of lists to facilitate e-Med Rec

Similarly, New Zealand's e-Medicines Reconciliation (eMR) captures a patient's medication history from two or more sources. The medicines are then matched with the patient's admission medication (and subsequent transfer episodes) and any differences are electronically reconciled. eMR is currently carried out by certain district health boards in New Zealand. There is an approved standard relating specifically to Med Rec available in New Zealand. (Health Information Standards Organisation)

The Northern Ireland Electronic Care Record has a facility where you can view a patient's medication which are prescribed by their registered GP. It is also possible to view specialist medications prescribed by Northern Irish hospitals in the 'existing medications' section (Health and Social Care Board, 2017).

A pharmacist conducted Med Rec study in Taiwan made use of the patient's medication usage data provided by gaining access to their National Health Insurance medication database. This stores real-time prescription information (Lee *et al.*, 2013). This study highlights a Med Rec process streamlined by the access to a real-time ambulatory medicines information source. The occurrence of prescribing errors was found to be 'significantly reduced' with the availability of the central medication data bank.

IT can enhance Med Rec through use of an electronic system to perform Med Rec and facilitate the access of ambulatory medication lists. Electronic access to prescription information from the GP records and dispensed information from the community pharmacy could transform the Med Rec process. This would significantly reduce the administration time spent by clinical staff in acquiring this information by other means.

#### 2.7.4. Presentation of information from ambulatory medication lists

An online Med Rec solution implemented in a US hospital uses a longitudinal outpatient medication list as a HTML document that can be launched from within the hospital's EPR (Bails *et al.*, 2008). This list includes all information on all prescriptions issued to a patient from this institution. This list formed the core source to perform Med Rec. This medication list had a one-way interface with the EPR. So that any alterations made within the EPR involving prescriptions i.e. discontinuation/modification of a medication is transferred to the medication list, thereby updating the current list of medications. However, any activity completed directly on the list does not affect the EPR. This idea of a one-way interface is important for capturing episodic information.

Another feature this system is the option to enter 'historical' medications which are medications the patient was on prior to this healthcare episode that the physician didn't prescribe. This is an important information piece that is often overlooked, as many EPR's and

e-medication management systems allow for a prescription function but not a 'historical medication' function to view medications the physician did not deem appropriate to currently prescribe (Bails *et al.*, 2008).

How information from available medication lists in EPR's will be used, should be considered when designing Med Rec tools. It is important that existing information isn't affected through the compilation a new list for Med Rec. The Med Rec episode may be considered as a distinct and separate entity from historical information about previous prescriptions issued. Med Rec episodes could be captured, and time stamped as a way of recording the activity in real time.

#### 2.7.5. Presentation of information in an e-Med Rec tool

Some consideration should be given to the visual design of a Med Rec tool. Med Rec has often been thought of as the comparison of two lists of medication. This information should be appropriately presented in a simple and intuitive manner.

In a study performed in a Boston paediatric hospital, the admission Med Rec was changed in the system from a separate page in the EPR to an active structured process where each item is actively continued or held on a dedicated screen (Jonathan D. Hron *et al.*, 2015). This tool encouraged active Med Rec by strategic placement of the PAML. The PAML and the admission medication orders are side by side. In the tool the BPMH is featured on the left and the admission medication orders are on the right.

A longitudinal medication list is used to facilitate online Med Rec in a US hospital. This is the definitive list of medications for this cohort of patients as it has discharge medications and out-patient prescription information. It includes information such as the date a medication was started and the date of the last activity concerning the medication i.e. renewed/suspended/continued. One tool has used a split screen view showing the longitudinal medication list at the top and the current active inpatient orders underneath. The prescriber has options to either, continue medication, suspend the medication or change the dose or the frequency. When reconciliation of the medications is complete, the row

changes colour. This application also has a colour code for medication reconciliation status. The three categories are; none, partial or complete (Bails *et al.*, 2008).

A PAML builder which can document the BPMH using information transfer of 'current medications' as listed in existing clinical systems, discharge medication information from previous admissions and new data entry (Turchin *et al.*, 2007). For each medication entry, the system displays the clinical information source and the date of the last medication record update in that system. The left column details this medication list which is imported from four diverse sources. The right side of the screen represents the PAML builder. During the process of using the PAML builder the medicines in the existing list be validated or discarded based on the verification by the patient themselves.

A study which used e-Med Rec to establish predictors of validity of computerised medication records highlighted the importance of predominantly displaying the date of when a medication record was last updated or the date of the last prescription in a clinical information system. This can alert prescribers reviewing these lists that an entry may be outdated and consequently a possible inaccurate record. This study ascertained that the date when a record was last updated is an important 'indicator of accuracy' (Turchin *et al.*, 2007).

Well-designed electronic systems for healthcare processes should anticipate a physician's information needs and display the relevant information accordingly with minimal effort. The user interface should be simplified as much as possible. Judicious use of colour, strategic placement of medication lists, and appropriately highlighting dates and expired/as required medications were all seen as elements to be considered in the design of a Med Rec tool.

## 2.8. Workflow integration

Agrawal, (2009) recognized in a review that it is not merely the IT system that can help prevent medication errors but how it is implemented into the clinical processes and workflow or sociotechnical environment of the workplace. Clinicians can often manage vast amounts of clinical data within their workflow. They are often required to make clinical decisions very quickly and often in a time pressured environment which may limit an exhaustive review of a

patient's medication history from multiple sources of medication information (Zhu and Cimino, 2015). Incorporating new systems can be difficult in an already busy workflow and changing environment. Agarwal and Wu (2009) acknowledge that in order to implement a successful Med Rec system, the culture of the organisation and clinical workflow must be addressed. Communication and teamwork is required among a diverse group of healthcare professionals. It involves a multi-step process to be conducted in a collaborative manner. The design and implementation require translating a complex clinical workflow into a linear technological specification.

#### 2.8.1. Accessibility and editing rights

A study investigating a multidisciplinary approach to Med Rec in an academic hospital demonstrated that the mean number of medication discrepancies decreased from 0.5 to 0 per patient on admission and 3.3 to 1.8 on discharge (Varkey *et al.*, 2007). As a result of this study, pharmacists in the healthcare institution in question, were subsequently permitted to edit patient medication lists in the EPR in collaboration with prescribers to enhance accuracy. Permission to edit the information in a Med Rec tool could be tailored to an individual healthcare institution's policy on the personnel involved in the Med Rec process.

#### 2.8.2. Use of system alerts and mandatory functionality

An evaluation of a Med Rec system in an acute inpatient care facility used computerised alerts to improve reliability by ensuring physician compliance with the use of the system. Compliance improved from 34% to 98%-100% (Agrawal and Wu, 2009). In this instance the e-Med Rec tool was linked to the electronic documentation of clinical progress notes. Documentation is a well-established part of the physician's routine workflow. The reminder alert is invoked when the physician starts to document a clinical note and it performs a background check to assess if the e-Med Rec process has been performed. As shown in figure 9, if there has been no engagement with the Med Rec process then the tool calculates the time since admission. If it is less than 24 hours after admission a "soft-stop" or a reminder to complete the process is issued. If longer than 24 hours has passed the physician

is presented with a “hard stop” which prevents the completion of the clinical note. This tool has embedded logic that is only activated for Non-Consultant-Hospital-Doctors (NCHD’s) responsible for the patient.

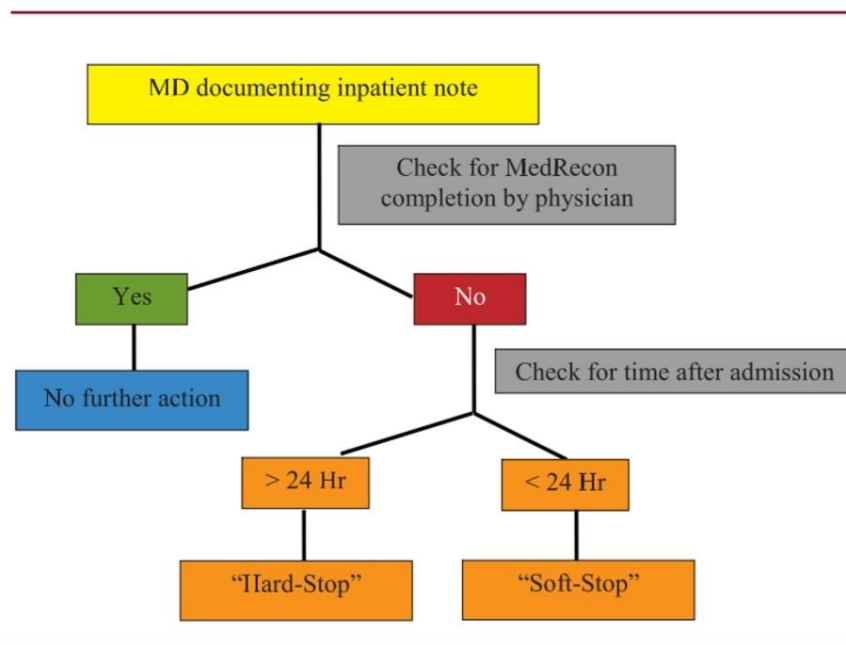


Figure 9. Reminder Alert Logic to improve physician compliance with the e-med rec process

Turchin *et al.*, (2011) concluded that interruptive alerts were seen to be an effective method of information delivery to users. This cluster pseudo-randomized control trial showed a significant relative increase in the utilisation of functionality. At an institutional level, use of functionality increased 2-fold. Anecdotally few clinicians attend training sessions due to time constraints. Use of alerts was suggested as a method of dissemination of information complementary to education sessions.

In 2006 the JCAHO mandated that all accredited healthcare facilities “must accurately and completely reconcile mediations across the continuum of care” (Agrawal, Wu and Khachewatsky, 2007). In a hospital in the US in 2007, Med Rec was made an obligatory part of the admission process. A blocking function was installed in the EPR which prevented medication orders if the Med Rec process wasn’t filled out within a 12-hour window. This saw Med Rec compliance increase from 20% to 90% (Bails *et al.*, 2008). Furthermore, this hospital

incorporated a mandatory discharge Med Rec process which saw compliance increase to 95%. A discharge summary could not be completed before the completion of discharge Med Rec. This highlights how mandatory functionality lead to adaption and subsequent integration of Med Rec into the workflow. In this instance mandating the Med Rec process was preferred over alerts as the mandatory compliance with Med Rec resulted in adaption and integration of Med Rec into the workflow.

An inquest into the death of a patient in Australia who died because of a prescribing error, made some recommendations around the use of alerts. The patient received medication intended for another patient. This report recommended reviewing and streamlining the alert system used in the EPR. The prescriber failed to notice the error despite the alerts triggered by the medical record software. The report considered the most effective way of ensuring patient safety without unduly distracting the clinician. The final recommendations included (Richardson *et al.*, 2018):

1. How to safely reduce the number of alerts,
2. Removing the default over-ride system,
3. The creation of a hierarchy of alerts,
4. Creation of distinct alerts
5. The effective use of font, format, sound, colour and placement of alerts,

The use of reminders and alerts have been investigated as a way of increasing compliance with the Med Rec process. They have also been used to provide information to the user about the functionality of the tool. While alerts may prove useful, there is a danger of alert-fatigue and user annoyance. An important consideration which may impact on patient safety is that mandatory completion of tasks can often lead to 'workarounds' by the user. Where alerts are being used in electronic systems it is important review, refine and balance their necessity to the user requirements.

### 2.8.3. Patient engagement with the e-Med Rec process

The HSE 2018 Service plan has referred to the desire to deliver patient-centred care which is responsive to the needs and values of the individual. It also refers to the inclusion of patients and service users in the design and delivery of this care (Health Service Executive, 2018). Personal health records (PHR's) allow patients to have greater control over their healthcare data and can capture a patient's use of nutritional supplements and Over-The-Counter (OTC) medication which can be clinically relevant. A prototype of an application was developed in the US using Harvard's SMART (Sustainable Medical Applications Reusable Technologies). The SMARTSync application reconciles medicines from the SMART EPR and Microsoft HealthVault PHR. This uses ontology-based recognition of interactions using the standards National Drug File Reference Terminology (NDF-RT) and RxNorm. Figure 10 depicts the SMARTSync architecture. NDF-RT is the underlying ontology and the system has a modular design, so data sources and the ontology can be extended and exchanged in the future. It also uses a Med Rec algorithm to compare the patient's documented medication list with that in the EPR. This system can provide a level of CDS and warn against the possibility of interactions and adverse reactions (Ziminski *et al.*, 2012).

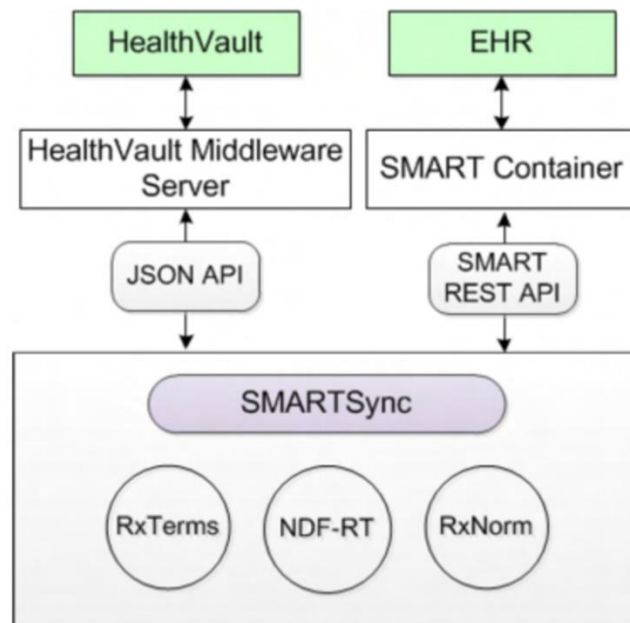


Figure 10. SMARTSync reconciliation architecture (Ziminski *et al.*, 2012).



The 2017 National Patient Experience Survey reported 'discharge or transfer of care' as the lowest rated stage of their hospital experience. Thousands of patients reported not receiving enough information with regard to medication side effects (Department of Health, HIQA and HSE, 2018). Involving patients in this process could empower them through increased knowledge and understanding of changes to medication regimens.

#### 2.8.4. Usability testing and evaluation

Data confirms that the success of developing and implementing technical solutions to support Med Rec is largely dependent on attention to implementation processes and extensive usability testing (Marien, Krug and Spinewine, 2017). Clinical processes must drive the development and design of medical IT solutions. Healthcare professionals must have the opportunity and be involved in the testing and evaluation on the usability and functionality and workflow (Marien, Krug and Spinewine, 2017). Lesselroth *et al.*, (2017) completed a naturalistic usability study on a Med Rec prototype which was developed according to pharmacists' requirements. Pharmacists logged into the software using portable tablet computers at the patient's bedside which supported a patient-centred adherence interview. Observations tended to centre around; interface usability, the relative usefulness of pictures to aid patient recall and medication identification, and the impact of a bedside interview. Feedback from the subsequent evaluation included, pharmacists desiring more interface flexibility regarding the sorting of information and the desire for the integration of biometric data.

Any well-designed e-Med Rec tool needs a system for evaluation. Evaluation is important before, during and after the implementation of an e-Med Rec tool. An essential part of assessing the success of the tool is measurement. It allows for the identification of successful elements and areas which could be improved. It is recommended that once implemented, employing methods to evaluate the effectiveness of an e-Med Rec solution must be adopted (ISMP Canada and Canadian Patient Safety Institute, 2017).

## 2.9. Conclusion

Practice of Med Rec is an internationally endorsed way of contributing to patient safety. It is important to strive towards standardisation of this process. The consideration of Med Rec as part of electronic medication management systems is a complex and understudied process. International literature has reviewed the different functionalities which should be considered part of the e-Med Rec solution. There is much to be learned from international experience with these systems to date. Drawing on this experience could inform further development of systems.

## Chapter 3. Literature review part II

### 3.1. Introduction

National and international progress in relation to e-prescribing is assessed in this chapter. This is relevant as the implementation of certain standards and integration in this area is complementary to and applicable to e-Med Rec solutions. The Irish eHealth eco-system and its current deficiencies will be discussed. International eHealth strategies will be reviewed with emphasis being placed on their approach to electronic medication management systems. This review was performed to assess existing international experience in this area, identify knowledge gaps, provide a rationale for further research and navigate the development of the research questions specific to an Irish setting. This chapter will present the results of part II of the literature review.

### 3.2. eHealth Ireland

The WHO defines eHealth as the ‘use of information and communication technologies for health’ (‘WHO | eHealth’, 2017). eHealth involves the integration of all information and knowledge sources involved in healthcare delivery through IT-based systems. The integration of health systems and processes is a key enabler in the transformation of the HSE, best practice health systems and optimum healthcare delivery (Health Service Executive, 2013). E-prescribing is an example of an eHealth system and is a priority project for the HSE as per the eHealth strategy.

The 2013 HSE document detailing Ireland’s ‘eHealth strategy’ documented that the total national spend on IT solutions was 0.85% by comparison to the EU range of 2-3% (Health Service Executive, 2013). IT infrastructure in the Irish healthcare setting care is highly fragmented. There is no connected approach to the provision of continuity of care to patients transitioning between primary and secondary care. The eHealth strategy outlines a roadmap and objectives with the intention of implementation through an ‘outcomes based’ delivery model. Healthcare in Ireland is changing rapidly with the growth and proliferation of

technology in all aspects of life. Healthcare systems of the future must adapt to the evolving needs of their stakeholders and patients.

There is no national e-prescribing system that contains details of patient's prescriptions issued by different prescribers. While Ireland awaits a national e-prescribing solution, most in-patient and discharge prescriptions are handwritten except in hospitals that have IT solutions. These systems can encompass e-prescribing and CPOE. These systems may not support the iterative steps in capturing the PAML or support the multi-disciplinary communication around the Med Rec process. The functionality and interfacing capabilities of these systems vary widely. E-Med Rec could be viewed as a potential function in an e-medication management system. The Irish Pharmacy Union which is the representative and professional body for community pharmacists, have issued a draft e-Prescribing User Requirement Specifications for Primary Care. Its purpose is to provide a pragmatic and comprehensive approach to the 'unique nuances of Irish work practices and legislation' (Irish Pharmacy Union, 2018). As we await the national e-prescribing solution, the following national standards in relation to messaging and datasets have been agreed and include:

- E-Prescription Dataset and Clinical Document Architecture Standard (Health Information and Quality Authority, 2015b).
- Data model for an electronic medicinal product reference catalogue- A National Standard (Health Information and Quality Authority, 2015a).
- National Standard for a Dispensing Note including a Clinical Document Architecture specification (Health Information and Quality Authority, 2016).

The Open NCP project is part of the Connecting Europe Facility for eHealth Digital Service Infrastructure in accordance with EU Directive 2011/24/EU (*Welcome to Information Architecture - eHealth Ireland*). This project aims to support the transfer of Irish patients' data from the summary care record and e-prescribing for unscheduled care. The aim is to provide continuity of care and achieve safe and quality transfer of information within the European Union (EU).

### 3.3. International eHealth

An international review was conducted by HIQA in six jurisdictions which have engaged with the e-prescribing process. This review was undertaken to inform the development of a strategy to consider the essential enablers to facilitate the electronic transfer of prescriptions. The countries reviewed have focused mainly on prescribing and dispensing in the community setting due to GPs and pharmacies having similar IT processes in their practices. These common IT processes facilitate easier interoperability and connectivity of systems. Medication management in a hospital setting is a far more complex system than primary care and makes computerisation and standardisation more difficult in this environment (Health Information and Quality Authority, 2015b). Med Rec was regarded as out of the scope of this review albeit recognised as highly important and clinically significant. A more recent report was published in May 2018 to further inform the Irish discussion around e-prescribing (Health Information and Quality Authority, 2018a).

Table 3 shows the results of survey of European Hospitals which was aiming to benchmark the deployment of eHealth initiatives. Results showed that the percentage of Irish hospitals with an integrated e-Prescribing solution is 9% by comparison to 100% in Estonia. E-prescribing was launched in Estonia in 2010. This has enabled relevant information to be readily available online for physicians at the point of care. Access is available to a full prescription history (*Digital Prescription | Drupal*, 2011). Physicians use computer software to prescribe medications which can then forward an electronic prescription to a national database (*EPrescribing in Estonia - EPSA - European Public Sector Award*, 2013).

Table 3. Adapted from the ‘European Hospital Survey – Benchmarking Deployment of eHealth Services (2012-1013)’ (Sabes-Figuera, 2013).

Country	% of Hospitals with integrated e-Prescribing	% of Hospitals with Medical Decision Support
Austria	16	26
Belgium	46	22
Czech Republic	45	35
Denmark	94	56
Estonia	100	41
Finland	81	27
France	39	24
Germany	9	24
Greece	94	7
Hungary	95	23
Iceland	67	33
Ireland	9	9
Italy	51	25
Latvia	5	11
Lithuania	12	22
Luxembourg	67	67
Netherlands	69	19
Norway	33	0
Portugal	93	15
Romania	84	22
Spain	67	35
Sweden	85	27
United Kingdom	20	9

The Health Information and Management Systems Society (HIMSS) is a not-for-profit organisation that designs predictive models, key data assets and tools to advise key stakeholders in health IT (Health Information Management Systems Society, 2016). HIMSS Analytics is a global healthcare provider of guidance and solutions in healthcare IT. They have assisted hospitals and clinical practices track and benchmark their adoption of the Electronic Medical Record (EMR) through their 8-stage EMR Adoption Model (EMRAM) (*About Himss Analytics | HIMSS Analytics - North America*, 2017). This model measures the adoption and utilization of EMR functions required to achieve a paperless environment which engages technology to support patient care. This model also provides a roadmap and guidance along with comparisons to healthcare institutions both nationally and internationally. Figure 11 demonstrates the EMRAM which incorporates methodology and algorithms which

automatically score healthcare institutions relative to their EMR adoption capabilities. The EMRAM may be perceived as an international standard of EMR adoption measurement. Appendix E lists in detail what is required for each level.

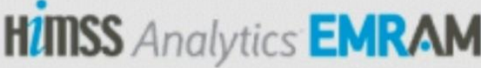
STAGE	 EMR Adoption Model Cumulative Capabilities
7	Complete EMR, Data Analytics to improve care
6	Physician Documentation (templates), Full CDSS, Closed Loop Medication Administration
5	Full R-PACS
4	CPOE; Clinical Decision Support (clinical protocols)
3	Clinical Documentation, CDSS (error checking)
2	CDR, Controlled Medical Vocabulary, CDS, HIE Capable
1	All Three Ancillaries Installed — Lab, Rad, Pharmacy
0	All Three Ancillaries Not Installed

Figure 11. HIMSS Analytics’ Electronic Medical Record Adoption Model (EMRAM / HIMSS UK).

### 3.4. Paper to Med Rec implementation Toolkit

The Institute for Safe Medication Practices (ISMP)- Canada and the Canadian Patient Safety Institute developed a toolkit for the implementation of an e-Med Rec systems. This is the result of a collaboration between the University of Victoria, informatics experts, the Institute for Safe Medication Practices Canada, the Canadian Patient Safety Institute and Canada Health Infoway. This toolkit supports organisations in their journey from the use of paper-based Med Rec tools to electronic solutions. A holistic approach is used, from the functionality required for a tool, to the healthcare organisation elements that need to be

considered to the subsequent evaluation of the process. This can be used as a case study of an international example of the e-Med Rec implementation approach.

A 2012 report identified that only 14.6% of healthcare institutions in Canada were using electronic tools for Med Rec. One of the top challenges was a lack of available IT to support Med Rec. A subsequent survey highlighted that of the organisations that were using e-Med Rec, 11% were fully electronic while 80% were using a paper-electronic hybrid approach. This toolkit was subsequently generated with the intention of supporting organisations to move towards implementing electronic systems for Med Rec. Participants from the 2013 survey were then invited to participate in a telephone interview to collect 'more detailed data' on their experiences. This toolkit acknowledges that in order to ensure the success in developing and implementing e-Med Rec is 'highly dependent' on the following (ISMP Canada and Canadian Patient Safety Institute, 2017);

- Implementation process
- Extensive usability testing
- Evaluation

Important considerations when implementing e-Med Rec as detailed in the implementation toolkit.

- ❖ Governance and leadership
- ❖ Assessment of organisation readiness
- ❖ Workflow Standardization, Organisational policy and procedures
- ❖ Selection of e-Med Rec Solution
- ❖ System Reliability
- ❖ Usability
- ❖ Sustainability
- ❖ Cost
- ❖ Patient Safety
- ❖ Risk Assessment
- ❖ Training and Engagement



### 3.5. Implementation strategy

e-Med Rec is a quality improvement initiative. To be fully embraced it needs to be incorporated into national and institutional environments. A systematic review acknowledged that the tools which were reviewed in the US and Canada had the support of national campaigns and incentives encouraging the progress of Med Rec since 2006 (Marien, Krug and Spinewine, 2017). At an institutional level it was found that endorsement by quality improvement leaders, highly integrated care, past experience of technology and a culture of promoting patient safety enhanced the adoption of e-Med Rec tools into routine use. Persuading frontline users and improving awareness of the importance of Med Rec among clinicians was also seen to be essential for success (Marien, Krug and Spinewine, 2017). Workflow redesign was recommended as one of the main measures to increase compliance with the process.

An international review of e-prescribing conducted by HIQA aimed to inform the discussion around e-prescribing in an Irish setting. This report acknowledged that each country reviewed had a clear strategy outlined and there was a 'single national authority responsible for realizing the vision'. Such an authority was responsible for the governance of standards for example their development, engagement of stakeholders and managing national broker services. The authority may also have the remit to ensure compliance with these standards. This international review by HIQA acknowledged the importance of 'visionary' leadership and local engagement. Programme leaders worked to understand stakeholder requirements but also balance their needs with their own overall vision (Health Information and Quality Authority, 2018a). It was also observed that a phased approach allowed for momentum to be built from successful pilots.

By using quality improvement methods and reliability science a successful admission e-Med Rec process was developed and sustained in a large teaching hospital in the US. The Model for Improvement was used as a framework. As outlined in Table 4, this model involved effective leadership, definition of roles and responsibilities, creation of a reliable system and a sustainability plan.

Table 4. Strategy for the implementation of a quality improvement program to optimize Med Rec (White *et al.*, 2011).

Strategy	Action
Leadership	To support and sustain a safety culture.
Simplification and standardisation of the electronic Med Rec app	Internal development of an e-Med Rec program.
Clarification of roles and responsibilities	Algorithm for compliance and accountability for process, identification of process champions, reminders.
Creating a highly reliable and visible system	Automated data reporting system, weekly review of compliance.
Sustainability	Handover, written updates, training, presentation of results and performance review.

Introducing e-Med Rec as a process on a local and national level requires a definite strategy. Leadership is a crucial factor to ensure local engagement and drive the strategy. Other factors centre around standardisation of the process, definite roles and responsibilities and system reliability.

### 3.6. Enablers for Integrated eHealth initiatives

#### 3.6.1. Individual Health Identifier

The Individual Health Identifier (IHI) is an important enabler for integrated electronic health. The Health Identifier Act 2014 proposes two national data collections. These are the National Register of Individual Health Identifiers and the National Register of Health Service Provider Identifiers. This will allow for the IHI record to store the IHI number and other personal data. These registers will provide a unique number for everyone using Irish healthcare and social care services. This includes both patients and healthcare providers. The IHI is not currently in operation. This must be fully functional before any formal implementation of shared medication records. The challenge for healthcare institutions will be integrating their existing patient administration systems with the IHI. Existing systems may require new functionality to facilitate this.

### 3.6.2. Integrated Medication Records

In the Irish setting, EPR or CPOE systems are not linked to a community pharmacy records. They only have access to information relating to a patient's medication which is prescribed at that institution. Likewise, community pharmacies in Ireland have no direct access to prescribing records. Paper based Med Rec doesn't take advantage of the information that is present in existing computerized resources and cannot be easily integrated with subsequent points of patient care such as CPOE (Turchin *et al.*, 2008).

Denmark has a regional electronic medical record which integrates an SMR. The SMR is a central database and provides full access to Danish patients current medication and medication prescriptions for the previous two years (Danish Ministry of Health, 2012). A study by Munck *et al.* (2014) examined whether SMR integration could facilitate clinician generated Med Rec. This study found that integration from the SMR to a hospital EPR was 'feasible and useful'. Patients have access to their own SMR and any clinician involved in the care of that patient has access to the patients SMR either through the hospitals or the GP's EPR.

### 3.6.3. Interoperability

Interoperability is the ability to share standardized information into unaffiliated systems. A satisfaction survey was completed by Turchin *et al.*, (2008) evaluating e-Med Rec. The results from the survey acknowledged the need for standardized interoperability as opposed to customized mapping, between the information contained in these tools and the propagation of this information into CPOE and also future information exchange between multiple healthcare systems.

Elysee, Herrin and Horwitz, (2017) acknowledge that the two fundamental cornerstones for an effective functioning Electronic Health Record (EHR) are health information exchange and interoperability. Data from other settings is crucial to resolve and prevent unintended errors occurring in medication histories. An observational study examined the relationship between electronic health information exchange, interoperability and Med Rec. As displayed in figure 12, this study described the interoperability capability as the *producer* of standardised useful clinical information, the electronic health information

exchange capability as the *exchanger* of information between healthcare providers, and the Med Rec capability as the *demand* of such information (Elysee, Herrin and Horwitz, 2017).

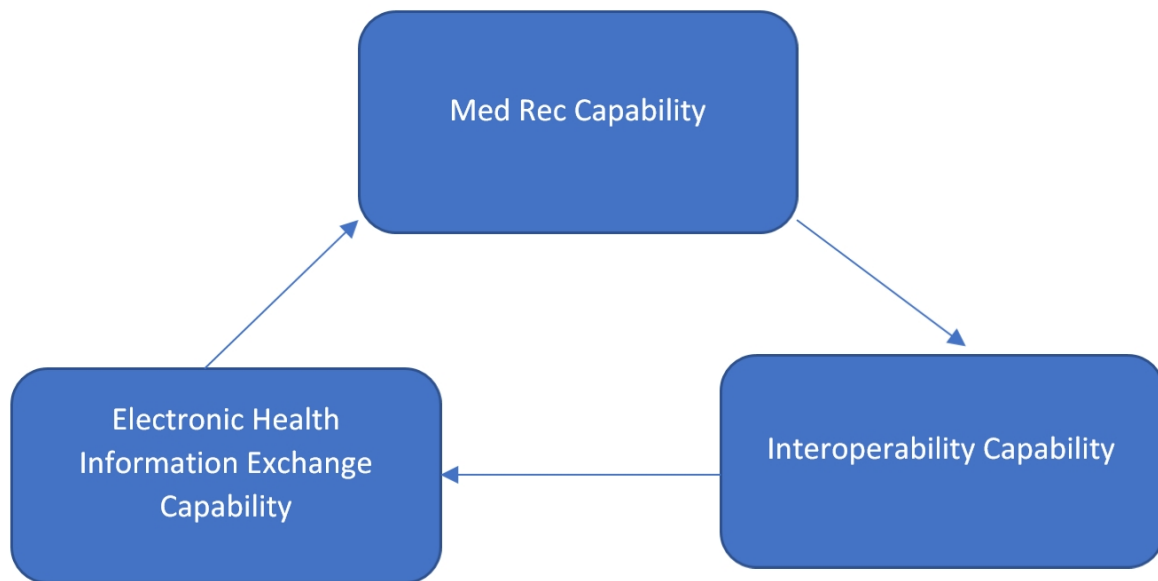


Figure 12. Relationship between interoperability, Electronic Health Information Exchange and Med Rec. Adapted from (Elysee, Herrin and Horwitz, 2017).

This study concluded that the relationship between healthcare providers' adoption of these three concepts are significant, positive and cyclical. If one decreases, the others will also decrease. Electronic exchange without interoperability could potentially introduce opportunities for error as non-standardised information may be interpreted differently at varying institutions. The authors of this study suggested that these findings should influence policy makers. They proposed that the adoption of interoperability be maximized by increasing the incentives for hospitals that implement rigorous standards. It was argued that this could increase the availability of data not just within the hospital's local systems but it could increase demand for further information sharing among policy makers in other healthcare institutions (Elysee, Herrin and Horwitz, 2017).

#### 3.6.4. National Medicinal Product Catalogue

After implementing a Med Rec tool that aggregated lists of medication from four different electronic sources, Poon *et al.*, (2006) acknowledged that the different medication terminology used by the different sources posed a challenge. An obstacle to a fully functional shared medication patient record that contains patient prescription details is the current lack of an agreed National Medicinal Product Catalogue. HIQA have defined a medicinal product catalogue as an “electronic dictionary of medications available for prescribing and dispensing”(Health Information and Quality Authority, 2015a). HIQA have concluded in their report, which is based on international research that the catalogue should be limited to “product identification, medicinal product names, strength, pack information, price, ingredient substances, legal status, form, units of weight, volume and strength, supplier identity and reimbursement information” (Health Information and Quality Authority, 2015a).

For fully functional e-prescribing, medicinal products must have a code identifying the medication to be dispensed. This could be under a trade name or a generic name. Other relevant information pertains to the dose, frequency, duration of a medication, whether or not the product can be substituted for a generic medicine and the number of times the prescription may be repeated. Use of an electronic medicinal product catalogue may facilitate this information transfer. Medication-specific information relating to the active ingredient(s) of these products are contained in such catalogues. A national catalogue needs to meet the requirements of hospitals, GPs and pharmacies. Currently there are at least five such catalogues in operation in different healthcare settings.

Ontologies are “formal and explicit specifications of shared conceptualizations” (Ziminski *et al.*, 2012). Medical ontologies are used in the healthcare IT. A single ontology to serve the entire medical domain does not exist, therefore Ziminski *et al.*, (2012) suggests that a successful Med Rec tool should be designed towards the usage of multiple dictionaries.

### 3.6.5. Audit

There are limited uses for blockchain but one of them could be for the purposes of audit and the facilitation of Med Rec. Blockchain technology is a digital ledger in which transactions made using cryptocurrency can be recorded chronologically. The original blockchain is an open-source technology which includes a collective 'verification of the ecosystem' which affords traceability, security and speed (Bradley, 2018). There is interest in using blockchain technology in healthcare where medical information could be stored on a virtually incorruptible database, maintained by a network of computers and accessible to those running the software (Landrein, 2017). Therefore, when a physician adds to the blockchain, this would become part of the patient's record irrespective of the computer system they use, circumventing issues around interoperability. A custom-built healthcare blockchain would need to be constructed to facilitate this.

A prototype for an EHR using blockchain technology envisaged a decentralized record enabling local and separate storage of patient data yet allowed for coordinated viewing of medical records (Ekblaw *et al.*, 2016). A blockchain Med Rec prototype with an authentication log governs access to medical records while allowing for auditability and data sharing (Ekblaw and Azaria, 2016). Its modular design enables interoperability which is convenient and adaptable. Figure 13 outlines the system architecture of this Med Rec app. A physician may add a new record through the app provider. The information is stored in the provider information system and a reference to the data complete with the appropriate viewing permissions is posted to the blockchain through an Application Program Interface (API). A patient may then retrieve this information from the providers database while the database gatekeeper can confirm access and ownership through checking the blockchain.

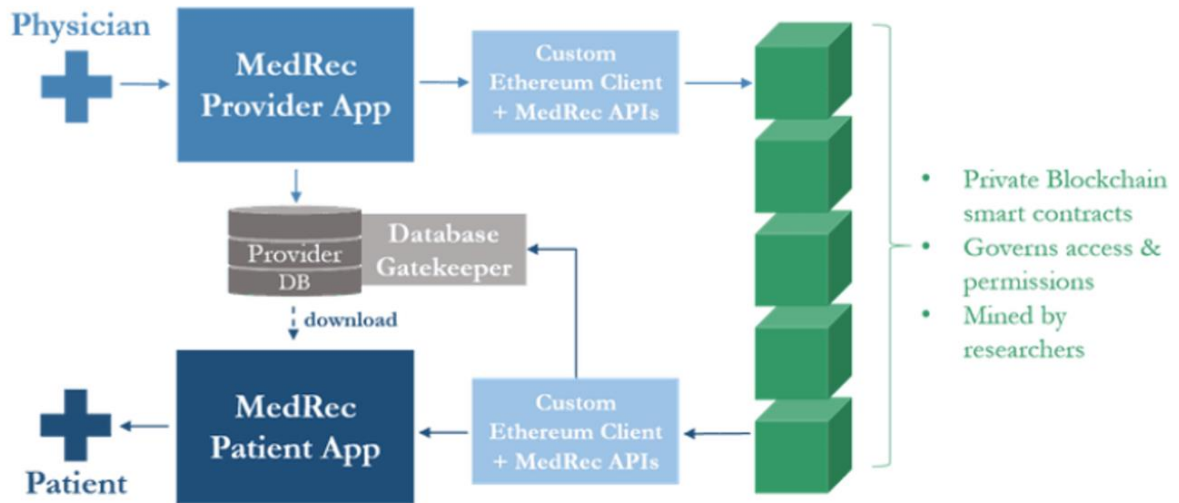


Figure 13. Blockchain Med Rec System Architecture (Ekblaw and Azaria, 2016).

### 3.7. Conclusion

There are current deficiencies within the Irish eHealth ecosystem. There are lessons to be learned from international experience from developing an e-Med Rec prototype to formulating a strategy for local and national implementation in an Irish setting. The next chapter will discuss the methods used to conduct this research.

## Chapter 4. Study Design and Methodology

### 4.1. Introduction

Chapter 2 has discussed the topic of Med Rec, outlined the available literature relevant e-Med Rec tools and functionalities. Chapter 3 has outlined international experience around eHealth initiatives and discussed the various eHealth deficiencies on a national level. This chapter will revisit the research question, aims and objectives. The study design and methodologies used to address the research question will be discussed.

### 4.2. Rationale of research question

As discussed in the literature, Med Rec is a highly variable process. The process can vary between institutions and often individuals. Collection tools can be paper-based, paper-electronic hybrids and fully electronic. E-Med Rec tools have been developed at an institutional level both nationally and internationally. A universally acceptable solution has yet to be agreed on and a strategy to promote this remains to be developed. This study will attempt to begin the process of developing a prototype for an Irish setting.

### 4.3. Research Aim

“Towards a prototype and strategy for electronic medication reconciliation capture in e-medication management systems in an Irish acute care setting”

To work towards addressing this research goal, the following will be developed through this study;

1. An evidence-based, user-informed ‘gold-standard’ list of functional requirements for an e-Med Rec tool for use in electronic medication management systems in an Irish acute healthcare setting.
2. A proposed graded classification of e-Med Rec tools.
3. Development of key elements of a proposed strategy for the promotion of e-Med Rec on the Irish Health Agenda.



#### 4.4. Research Objectives

- ❖ To review the relevant literature and identify the lessons learned regarding the functionality that is necessary for e-Med Rec tools.
- ❖ To review the relevant literature to see what the essential enablers for eHealth solutions in Ireland are.
- ❖ To interview key informants to ascertain their opinions on the functionality that is required for an e-Med Rec tool.
- ❖ To develop a proposed classification of the functionality of an e-Med Rec tool desired by end users and key informants.
- ❖ To explore how an e-Med Rec tool could fit into the workflow in the Irish healthcare setting.
- ❖ To propose a strategy for prioritizing e-Med Rec in the Irish healthcare setting based on international experience and the opinions and guidance of key informants.

#### 4.5. Research Design and Strategy

The research design structure is the outline of methods chosen for how the investigation took place. It is hoped to ensure that sufficient evidence is obtained to effectively address the research aims and objectives as logically and unambiguously as possible.

The literature was reviewed to inform a method for the completion of this research. A study in Denmark which examined complex Med Rec instances for patients transitioning between healthcare providers used literature review, semi-structured interviews and demonstration via a use case to examine their objective (Tarp *et al.*, 2017). National strategies and government reports in relation to eHealth initiatives and more especially e-prescribing were reviewed and the methodologies they utilised examined for informing the research approach to be followed for the purpose of this study. The eHealth Strategy (2013) document was developed through the review of literature and analysis of international eHealth strategies, deployment and implementation experience. This information culminated in the

outline of recommendations for the national implementation of eHealth initiatives for Ireland as outlined in figure 14. This method draws on the experience of other countries and formulates recommendations which are specific to an Irish setting.



Figure 14. Methods used for the development of Ireland’s eHealth strategy (Health Service Executive, 2013).

The recent HIQA international review of e-prescribing models examined national health models, governance, leadership & stakeholder engagement, process & system design, common standards and implementation approach (Health Information and Quality Authority, 2018a). The findings are intended to inform the discussion around e-prescribing for an Irish setting. Once again, international experience and lessons learned were reviewed to direct a possible approach which could be adopted for an Irish setting.

Many authors hold the method of interviewing in qualitative research as the gold-standard to elicit comprehensive exchanges between the researcher and participants. In the development of a Canadian e-Med Rec Implementation Toolkit, (ISMP Canada and Canadian Patient Safety Institute, 2017) phone interviews were used to get more detailed data in relation to participants experience of e-Med Rec. Using a qualitative approach is befitting of the complexity of the topic of Med Rec. It was anticipated that semi-structured interviews would permit a richer depth for discussion to build on the experience documented in the literature. Where e-Med Rec tools have been designed and implemented, it has been noted

that it is the users of the tool that provide the most informative information and feedback to further improve the tool (Groeschen and Provost, 2007).

Modern healthcare systems can be viewed as 'socially complex' organisations which can serve as 'fertile grounds' for wicked problems (Periyakoil, 2007). The Med Rec process could be viewed as a Wicked system as it has some of the inherent characteristics of these systems which are as follows (Hevner *et al.*, 2004);

- ❖ Unstable requirements and constraints based upon ill-defined environmental contexts.
- ❖ Complex interactions among subcomponents of the problem and its solution.
- ❖ Inherent flexibility to change design processes as well as design artefacts.
- ❖ A critical dependence on human cognitive abilities (e.g. creativity) to produce effective solutions.
- ❖ A critical dependence on human social abilities (e.g. teamwork) to produce effective solutions

There are complications around agreement and implementation of the Med Rec process. Therefore, a design-science approach will be used as this supports the iterative nature of this work. Figure 15 outlines the research guidelines for design-science.

<b>Guideline</b>	<b>Description</b>
Guideline 1: Design as an Artifact	Design-science research must produce a viable artifact in the form of a construct, a model, a method, or an instantiation.
Guideline 2: Problem Relevance	The objective of design-science research is to develop technology-based solutions to important and relevant business problems.
Guideline 3: Design Evaluation	The utility, quality, and efficacy of a design artifact must be rigorously demonstrated via well-executed evaluation methods.
Guideline 4: Research Contributions	Effective design-science research must provide clear and verifiable contributions in the areas of the design artifact, design foundations, and/or design methodologies.
Guideline 5: Research Rigor	Design-science research relies upon the application of rigorous methods in both the construction and evaluation of the design artifact.
Guideline 6: Design as a Search Process	The search for an effective artifact requires utilizing available means to reach desired ends while satisfying laws in the problem environment.
Guideline 7: Communication of Research	Design-science research must be presented effectively both to technology-oriented as well as management-oriented audiences.

Figure 15. Design-Science Research Guidelines (Hevner *et al.*, 2004).

## 4.6. Research Methods

### 4.6.1. Introduction

A combination of research methods was used to address the research question. These methods consisted of a literature review and semi-structured interviews. Figure 16 represents the entire research process undertaken for this study. The red line represents the fact that this process should be thought of as an iterative process. As stated in the literature the development of a prototype is an iterative process and a design science approach was deemed appropriate by the author for the nature of this investigation.

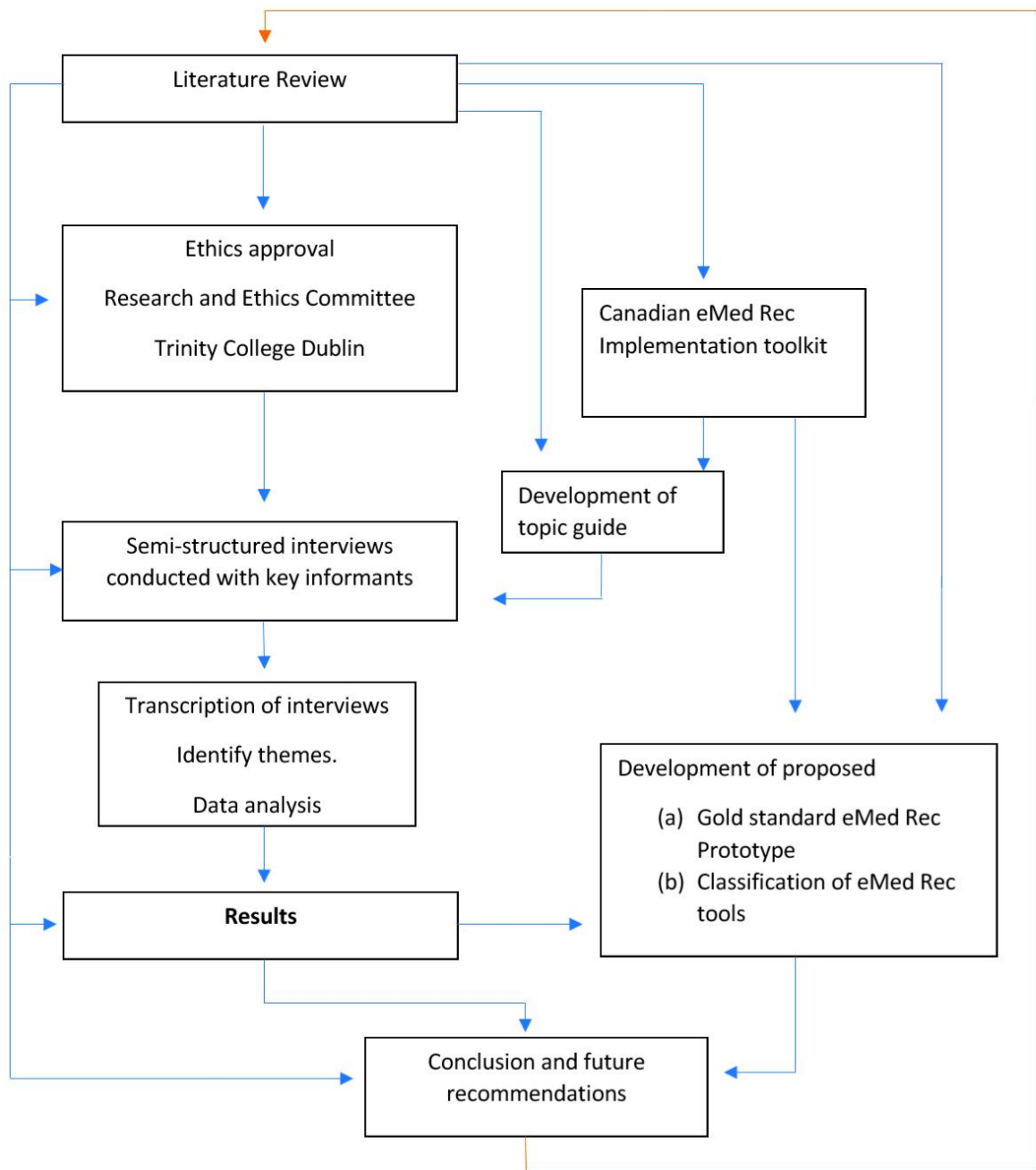


Figure 16. Overview of research process

#### 4.6.2. Clarification of Med Rec and BPMH

To ensure validity and reproducibility of the study, it is important to outline and reinforce the definitions of Med Rec and Best Possible Medication History (BPMH). For this research Med Rec is defined as:

“The process of identifying the most accurate list of medication that a person is taking – including name, dosage, frequency and route- and using this list to provide correct medications for patients anywhere within the health system. Reconciliation involves comparing the patient’s current list of medications against the physician’s admission, transfer or discharge orders” (*Institute for Healthcare Improvement: Accuracy at Every Step: The Challenge of Medication Reconciliation, 2018*).

For successful Med Rec the ‘most accurate’ list of medication must be obtained. This may be thought of as the BPMH. The concept of a ‘gold standard PAML’ was proposed by Pippins *et al.*, (2008) as a list compiled using all available sources of information including interviewing the patient or carer to generate the most complete list of medication that the patient was actually taking.

#### 4.6.3. Development of Topic Guide

The eHealth Ireland strategy and HIQA report used international experience to inform recommendations for an Irish setting. Following a similar pattern, this research was initially informed through a literature review. From the author’s reading of the literature, the recurring themes were grouped under three headings. These concepts were observed to be functionality, workflow fit and essential enablers. Appendix F outlines the papers reviewed and deemed relevant for inclusion in the literature review. The occurrence of the above three themes in these papers was identified and documented in this table. A fourth ‘strategy’ theme also emerged from papers which also looked at implementation approaches and from HIQA eHealth international reviews and Canadian Implementation Toolkit.

Therefore, the four main themes that emerged from the literature were:

- Functionality
- Workflow fit
- Enablers
- Strategy

A topic guide was subsequently developed under these headings. The fourth 'strategy' theme was also a recurring theme focuses on the importance of:

- Governance  
Leadership
- Standardization
- Organisational policies and procedures.

The final interview topic guide is featured in Appendix G.

#### 4.6.4. Development of Interview Prompt

A list of proposed ideal features of an e-Med Rec Tool was compiled from a combination of recommendations from the Canadian Implementation toolkit and a table summary from a systematic review conducted by Marien, Krug and Spinewine, (2017). The resulting list was refined by the author and intended for use as an interview prompt (Appendix H). The intended purpose was to provide a guide and tool which could be used to assess the findings of the functionality question in the interviews. This prompt was e-mailed to participants ahead of the interviews for their consideration. Fifty percent of the participants interviewed face to face, used the prompt to systematically discuss or rank the functionality outlined.

#### 4.6.4. Semi-structured Interviews

Semi-structured interviews were conducted with pre-identified key informants and stakeholders. Key informants were identified from a range of work divisions. Key informants were sought to represent the following areas; medication safety, pharmacy, health informatics, healthcare regulation, general practice and hospital medicine. These were picked based on the strategic areas outlined in table 4. A variety of stakeholders was chosen to get

a range of perspectives of the Med Rec process Table 5 details a key informant analysis of the interviewees.

Table 5. Key informant analysis

<b>Job title</b>	<b>Area of work</b>	<b>Interest area</b>	<b>Current Role</b>
Head of Healthcare Regulation	Regulation	Regulation	Leadership
Chief II Pharmacist, Quality Improvement Division	Hospital/Government Body	Medication Reconciliation. Medication Safety.	Leadership
GP	Primary Care	E-prescribing. Primary Care. General Practice IT	Leadership
Chief II Pharmacist and Quality Manager	Hospital	Medication reconciliation. Clinical pharmacy service provision. Quality and Risk.	Leadership
Clinical Pharmacist.	Hospital	Clinical Pharmacy. Electronic prescribing.	Service provider
Hospital Doctor and Computer Scientist	Hospital	Electronic prescribing. Medicine.	Service provider
Chief Pharmacist	Hospital	Clinical pharmacy service provision.	Leadership
Chief Pharmacist	Hospital	Clinical pharmacy service provision. Pharmacy IT.	Leadership
Chief Pharmacist	Hospital	Clinical pharmacy service provision.	Leadership
Superintendent Pharmacist and health informatician	Primary Care	Community pharmacy service provision. Health informatics.	Leadership

A letter of invitation as depicted in Appendix I was sent to identified key informants via email. Interviews were conducted over a three-week period with ten participants. Five interviews were conducted face-to-face and five interviews were conducted via telephone. All interviews were recorded and transcribed in full by the author.



#### 4.6.5. Synthesis of research output

The text of the interviews was reviewed by the author and emerging themes were identified and coded. Both inductive and deductive approaches were used to analyse these interviews. Combining the results from these interviews and the findings from the literature review will culminate in a proposed 'gold-standard e-Med Rec list of functionality requirements as outlined in figure 17.

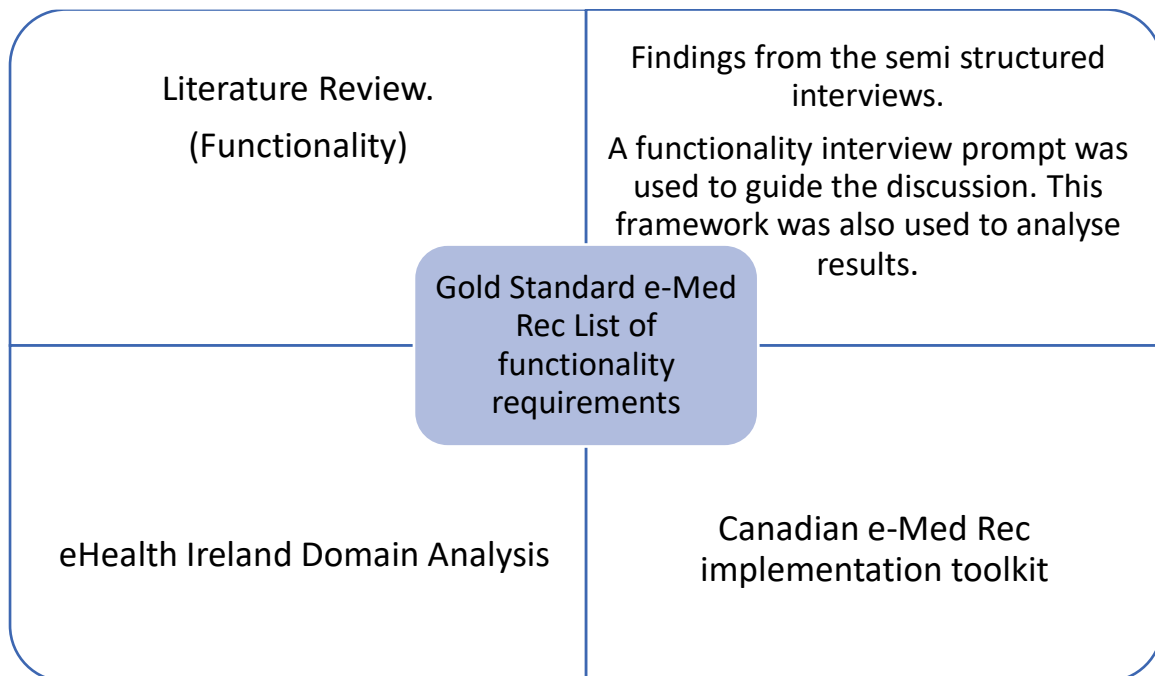


Figure 17. Methods for the development of a proposed gold standard list of functionality requirements for an e-Med Rec

Leading on from the acquisition of this first aim and using this in combination with the results from the literature review and interviews, a graded classification of Med Rec tools will be proposed (figure 18). A maturity models for Health Information Systems proposed by Carvalho *et al.*, (2017) allows healthcare institutions to define their current maturity stage, determine the next achievable maturity stage and determine the attributes that must be met in order to reach the next maturity stage.

The six maturity influencing factors included in this maturity model are as follows:

- Data analysis
- Strategy
- People
- EMR
- Information security
- Systems and IT infrastructure

Following the same concept where the HIMSS EMRAM model can be viewed as an international standard for EMR adoption and starts with the most basic system, it outlines what milestones need to be achieved to obtain a stage 5 or gold standard EMR which is a near paperless solution. The research aims to propose an e-Med Rec graded classification of tools, moving from a paper model to a gold standard e-Med Rec solution. The highest level should achieve all the advantages as documented in the literature and outlined in Table 2. This proposed graded classification would require validation. This however, is outside of the scope of this report. Validation of this classification system would be part of the proposed future work.

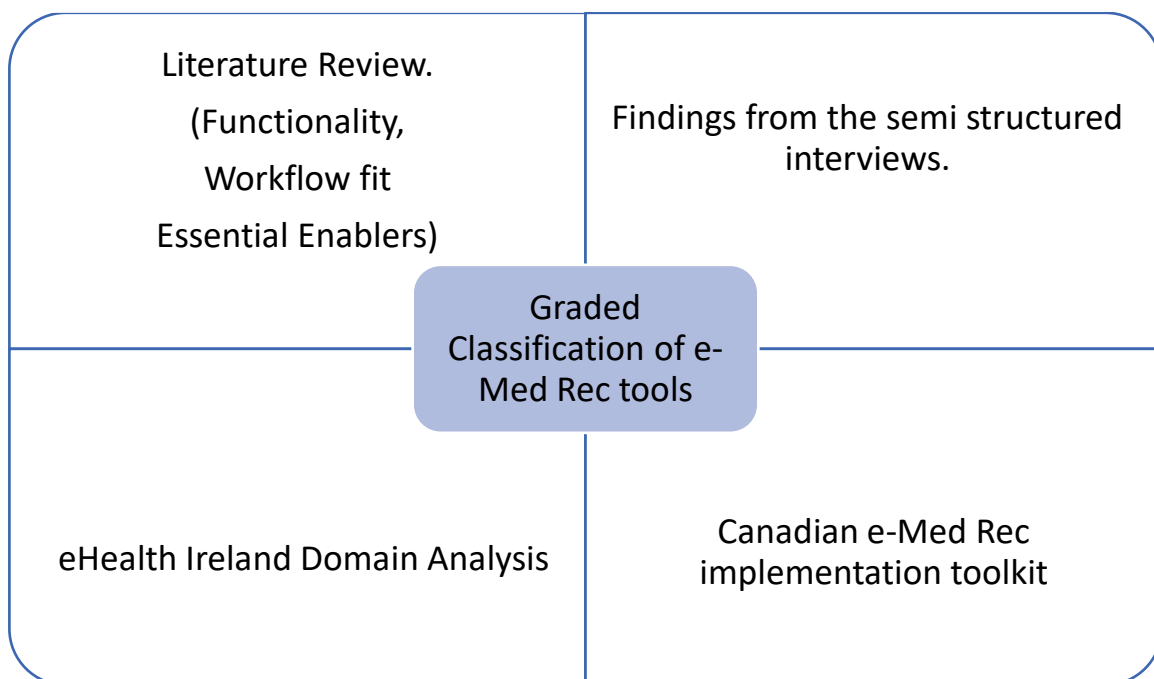


Figure 18. Methods used for the development of proposed graded classification of e-Med Rec tools

#### 4.7. Ethical considerations

To address any ethical concerns participants were provided with an information sheet (Appendix J) prior to interviewing, explaining the purpose of the study. Participants were requested to return a consent form as shown in (Appendix K). An application was submitted to the Research and Ethics Committee of the School of Computer Science and approved. Approval was received on the 20/4/18 (Appendix L).

#### 4.8. Conclusion

This chapter provides an outline as to the how the aims and objectives of this study were achieved. The motivation for selecting the chosen research design has also been discussed. The next chapter will present the results and analysis from the semi-structured interviews.

## Chapter 5. Results and Analysis

### 5.1. Introduction

The main consistent and strongly emerging themes were identified, coded and grouped together for extracting common trends and discrepancies between concepts. Table 6 summarizes the main themes and sub-themes under the topics informed by the literature. Quotations of interest from the interviews will be presented in this chapter. The results will be synthesised into a table and diagram and discussed against the backdrop of the literature in the next chapter.

Table 6. Themes and subthemes identified from interviews.

<b>Theme</b>	<b>Subthemes</b>
The Challenge	
Benefits	
Functionality	Simplistic system Sources of pre-admission medication lists Allergy Documentation Professional Verification Concept of Gold Standard e-Med Rec tool
Workflow fit	Pharmacy-led solution Training
Enablers	Standardisation National Medicines Catalogue Clinical Champions Central Medicines Repository Accessibility and Integration
Strategy	Interprofessional Collaboration Patient Focused Benefits Department of Health and eHealth Ireland HIQA

## 5.2. Results

### 5.2.1. The Challenge

All interviewees acknowledged the challenge of communication across the interfaces of care and the complexity of Med Rec.

*“I mean, why is it so difficult? And bearing in mind there is a variability as to how much a doctor is going to do Med Rec. It seems to be like- we do it. But, it's almost like for a pharmacist; it's a very specific task that needs to be done properly, with rigour and there's a reason for it. And not that it's not important in medicine, of course it's really important. But because it's never, or at least it's not talked about in terms of it being a specific job. it's just like; make sure you get the medicines right.”*

[Interviewee 5]

*“It's so complex when you start to break down the steps because you do want to make it standardised across, (as you alluded to earlier) pharmacists and pharmacies and hospitals. So how do you reconcile those two things, by making it simple but keeping it comprehensive?”*

[Interviewee 6]

*“And if you think about patients going over and back across the interface, all the time as some of them do, there's a whole amount of potential for error.”*

[Interviewee 7]

*“How do we make the communication around medicines or prescription information seamless from the community to hospital, transfer and out of hospital again.”*

[Interviewee 8]

*“This is a health Informatics problem. At the moment it's been flagged as a workforce issue, but we will never have enough money in the Health Service to resource this if we don't look at it differently. I for one would strongly advocate for the use of technology. We need to mitigate risk as much as we can.”*

[Interviewee 10]

### 5.2.2. Benefits

It was acknowledged that the use of technology could allow for many benefits including improved communication, more efficient use of pharmacy resources.

*“The more you automate and the more you speed up the transfer of information.”*

[Interviewee 7]

*“So, if we can simplify that first time consuming piece (of information gathering), you can free up time to do the bit that actually matters.”*

[Interviewee 5]

*“With electronic systems, you know one person can't be everywhere, but they can cover a lot more ground with access to information through a system like this.”*

[Interviewee 10]

### 5.2.3. Functionality

#### 5.2.3.1. Simplistic system

There was a unanimous desire among the interviewees for a simple system.

*“Don't make it complex. The more complex the system, you lose out on the main concept of patient safety.”*

[Interviewee 4]

*“I'm a fan of less is more. A minimal viable product.”*

[Interviewee 5]

#### 5.2.3.2. Sources of pre-admission medication lists

There was a unanimous agreement among those interviewed, in the desire for access to ambulatory medication lists from prescribers and the community pharmacy. There was also interest in an automatic reconciliation between what is prescribed and what is dispensed.

*“I suppose to summarise what you want is “A Single Source of Truth”. So, you want to get a record of medication that is the medication that the patient is actually taking. This might also include what the patient thinks they are taking, but they are not for whatever reason, they may be prescribed but not actually taking. And also, historical records of medications that a patient might have been taking in the past and the reasons why they're not taking them.”*

[Interviewee 3]

Having the patient as a key data source was expressed as a highly desirable feature.

*“That should be a forced function I think. You'll have the lists, but you'll still need somebody to decide what the best possible medication list is. I mean the system can prescribe or the doctors prescribe or whoever is prescribing, but it's really down to what the patient is taking. And that brings compliance in. So, if you really do want to take account for that, you need that verification, either by the patient accessing and maintaining their personal health record, or their carer or the pharmacist being skilled to navigate that conversation.”*

[Interviewee 6]

*“But in terms of gold standard -I like your idea that the patient verifies the medication, and everything fits with what they think.”*

[Interviewee 9]

There was a mixed reaction towards the inclusion of accessing personal health records as a source of pre-admission medications. Those who affirmed the desire to have patients accessing the tool added that they would also like to see additional functionality that would empower the patient in their own personal management of their medicines.

*“One thing I might add about having patients having access. One of the things I'd say is to design things to include that. The patients that are elderly today are probably not going to want that kind of access. But the patients that will be elderly in 10 or 15 years will. Because they live their lives online. And it won't be any different then.”*

[Interviewee 7]

*“Yes, I think it would be a nice feature. It brings you to a different context and a different space as well. Where, let's say a new entry is made on the national prescription record and that new entry interfaces with your app on your phone and you could use it as a communication reminder, or a record that you show somebody, or you have a conversation or something which allows you for example when you tap on a drug, you can say- well I don't like that one because I'm getting nightmares, or whatever. So, I do think, the information transfer to the patient would be a very useful thing to help them manage their medicines and provide feedback on how they're doing with their medication.”*

[Interviewee 8]

*“All the evidence says that patients being involved in their care and being empowered and taking more involvement in their care is beneficial. But I think it needs to be a verification as opposed to an actual key data source. I would be quite cautious in terms of their level of involvement and how much we rely on that information.”*

[Interviewee 9]

### 5.2.3.3 Allergy documentation

The electronic documentation of allergies was agreed by interviewees to be a very desirable feature.

*“Allergies- I think that's essential. I think if someone has gone to the trouble of documenting it in the GP practice or community pharmacy I think it's important enough that we need to know about it I think. Really, really, important.”*

[Interviewee 2]

*“Allergies is kind of ok. It's taken care of for the most part. Every single admission form be it paper or electronic has an allergies box. But there's going to be an inconsistency as to whether people admitting patients put in intolerances, side effects, allergies and compliance issues in that box. Unless the EPR is set up in such a way that actually discriminates between compliance, side effects, allergies and intolerances then the only one that's captured there is allergies. The others are buried in the clinical notes in the EPR which won't be pull-able. Because I don't think that any system is set up that way. As far as I know unless this stuff is in a special box it's still siloed in the EPR.”*

[Interviewee 5]

*“Usually the quality of the information pertaining to allergies and intolerances is appalling. And sometimes there is no information. I think of fundamental part of medication reconciliation is capturing allergies and intolerances. And moving towards a lifetime record rather than an episodic one which needs to be refreshed and rechecked and updated every time a patient comes in.”*

[Interviewee 8]

### 5.2.3.4. Professional verification

There was an interest in professional verification and responsibility, while also a concern about including too many unnecessary steps.

*“I think it would be important to ensure both elements are clearly covered so anyone that picks up this information knows that it's not just someone that's gathered this information but it's a proper evaluation conducted by someone who's qualified and competent to do a Med Rec piece of work. So, I think it is important that there is some degree of clarity in relation to the status of the information in terms of how the information was gathered and by whom. There should be some responsibility and some qualified sign off at each stage of the process. There should be some responsibility taken for accuracy (versus what's there) of the information that's there. There should be governance over each stage of the process. There should be clarity of information from the community pharmacy to the hospital or from the GP practice.’*

[Interviewee 1]



#### 5.2.3.5. Concept of gold standard e-Med Rec tool

Agreement that it is possible to start with a relatively simple system and work towards achieving a more comprehensive system.

*“It doesn't have to have absolutely every functionality. The core functionality should increase patient safety and efficiency is all you need. The others can come in time. But I would not start off with a complicated system.”*

[Interviewee 4]

*“My only concern is, you have a lot of granularity [in the system you're proposing]. I think it may be that there's a go-live version and there's a gold standard version. We have to be realistic about what's feasible at the outset.”*

[Interviewee 10]

The importance of validation, iterations and piloting was highlighted by interviewees.

*“These are things to consider because you might not initially consider them and then you get to a point [in the development] and it could be a stumbling block. It's all got to do with the functionality being right. make sure it's been piloted, make sure it's been validated, all those things come into it.”*

[Interviewee 4]

*“I suppose we can't wait around for the eHealth strategy all the time either. The electronic health record and all of that will take years and there's no point putting any stalling on something that's already there. And then you just develop pilot iteration, and places can benefit from that.”*

[Interviewee 6]

*“When you think about how you can scale something up to a national scale, and you also have the problem that the electronic health record is coming down the track. That they're going to have this functionality in them. But I guess your argument is that it will be 10 years before the last hospital gets their electronic health record at least. And how much harm will happen, as a result of poor medication reconciliation before then?”*

[Interviewee 10]

#### 5.2.4. Workflow fit

##### 5.2.4.1. Pharmacy led solution

The consensus among the interviewees was that this solution should be a pharmacist led process. Resource limitation was a factor that was acknowledged and there was a suggestion that other professional involvement may be considered.

*“Certainly, there should be a requirement for additional responsibility in relation to this. No matter how many admissions and discharges there are, it's not possible to get for a pharmacist to perform Med Rec for every admission and discharge. It's important to acknowledge this. There should be processes and systems in place that can be used by everyone.”*

[Interviewee 1]

*“I think it has to be pharmacy led- whether that is pharmacy team lead or having a patient safety person involved or chief pharmacist it depends on the size of the institution. Then maybe potentially working with nurse practice development if you don't have a pharmacy team to lead it. I think it's probably quite hard to achieve if you don't have pharmacists leading it and probably undertaking most of it.”*

[Interviewee 2]

*“[Pharmacists] have a high education we are experts in medication. That is our job, that is our responsibility, so, I think yes, I absolutely do. It should be pharmacy led. The only thing is, you have to consider resourcing. It's ideal and It's important but you have to consider resource management.”*

[Interviewee 4]

*“The main thing is that pharmacists are the experts. Nurses are not qualified to be doing this. No doubt they would be pressure and a feeling that they should be doing this, but they're not qualified. You're talking about not having an accurate list or you're talking about the interactions and the way that the drugs combined together. Just the small things about product knowledge and formulation which may impact on a patient's ability to take medications, and all sorts of other things that are below the surface that they don't see and that they don't have a knowledge of. The productivity and value argument could be well pharmaceutical technicians are more qualified than nurses to do this, and they will be managed in a team which includes an experienced pharmacist.”*

[Interviewee 8]

#### 5.2.4.2. Training

It was agreed that the consideration of a training programme is essential throughout the design of a tool and also at the implementation stage.

*“Make sure that the training is exceptionally good before during and after.”*

[Interviewee 4]

*“I suppose from a quality point of view, I’ve seen NIMIS and I’ve seen how aspects of it, while you think it might mean one thing, as somebody coming to it without a radiology background, it might mean something completely different until it’s explained to you. So, I can understand what you’re saying about, different professions looking at a tool, that is maybe designed by one particular profession. Mapping the training as you develop for looking at what the training program is going to be like. Because that would force you to think about- well what does this particular thing actually mean. When you’re building the system, you’re building the training program. But you have to have the expertise where it’s actually happening, informing the message, and informing the design.”*

[Interviewee 6]

#### 5.2.5. Enablers

##### 5.2.5.1. Standardisation

There was a strong desire for standardisation of the process and an acknowledgement that an electronic solution could help to achieve this.

*“I think an electronic solution would help to push it. I don't think we're very good at standardising pharmacy services in institutions at all. I guess if there was some sort of an electronic tool that would push people in a particular direction. I mean you obviously have to get a lot of agreement as to what the tool will be, but I think agreement on a tool would drive it more than anything.”*

[Interviewee 2]

*“You're basically putting it into an electronic template. And that in itself is helping to standardise it.”*

[Interviewee 7]

*“People should have a national standardised approach and that involves some consensus building. Standardise as much as possible. Once things are standardised, it's a little bit easier to implement electronic solutions. This standardisation work needs to go ahead of the electronic health record. This medication reconciliation solution work. Having those kinds of conversations with clinical leaders early in the process and trying to move towards standardization. You're not going to standardise everything. But if you can get as much consensus as possible around the main elements.”*

[Interviewee 10]

#### 5.2.5.2. National Medicinal Products Catalogue

There was an acknowledgement that there are certain enablers such as agreement on a national medicinal catalogue that any tool developed will need to eventually accommodate.

*“I think the tool needs to be developed with the intention of all these factors feeding into it. You can do a lot without necessarily having them all in place, but I think anything that's developed now needs to think about what will happen when they become available.”*

[Interviewee 2]

*“Well yes that's another thing, the drug file. And coming to agreement on what we should use for that. We all need to talk the same language as far as that goes for an agreed drug file. But I think it's connectivity and interoperability is the keyword in anything that is involved in prescribing and dispensing. And that whatever early stages of electronic prescribing are done it should be designed in such a way that it should be fully interoperable with other systems. Which should be interoperable with each other.”*

[Interviewee 3]

*“You have to have a database, you have to have a National Product Catalogue.”*

[Interviewee 7]

#### 5.2.5.3. Clinical Champions

There was an acknowledgement in some of the interviews that in order for this to progress, clinical engagement and leadership at a senior level is required.

*“I think the main enabler really would that the project be sponsored by a clinical champion or sponsor at a very high level. So that the sheer scale of the problem and the risks involved, when we don't do this, are understood by medics who are making decisions about national programmes. And if you have that, then you get buy-in as well as being able to cost it. There is an awful lot of evidence out there in terms of the cost of getting it wrong. I think clinical sponsorship and financial sponsorship is the real enabler.”*

[Interviewee 8]

*“Clinical engagement is the biggest single issue. That kind of Clinical leadership is really important. Ideally, you'd have an obstetrician or a neonatologist on-site that's embedded in the project and is on the national calls and is involved in the change process. As a consequence of not having that on-site you tend to get these grumbings about the system, which festers into; we're not happy with this, we weren't consulted on this, none of our concerns are listened to.”*

[Interviewee 10]

#### 5.2.5.4. Central Medicines Repository

Most interviewees spoke about their desire for the concept of one 'single source of truth' or central medicines repository.

*“So, if the pharmacy in the GP are linked, you would only have one source there anyway. So, in the future that would be fantastic so that would be one point of entry. And you wouldn't even have to have a best list you would just have one list. Then there would be this one list, which could be compared to the hospitals list. And you can see differences quite easily. If you wanted for visibility reasons, it could be very handy to have; you have one list that the patient came in on and then you have another list beside it, and whatever changes there are.”*

[Interviewee 4]

*“I think it would be wonderful if it could be part of the electronic prescribing in its entirety. And the electronic patient record as part of that as well. Then you are really getting full visibility of what's happening right across.”*

[Interviewee 6]

*“So, they’re all these communication barriers, and this is why we really need and national cloud-based patient medication history repository. If there was an electronic prescription system, that you could go back as a pharmacist and see that it was there, there will be less likelihood that [a medication] omission would happen in the first place. If you had a national database, you’re not identifying medication anymore, you’re now only verifying them.”*

[Interviewee 7]

*“If I was building it from scratch I would say, we have a national prescription system and preferably one that allows for complete transparency that no matter where you are in the country, and no matter whether you're in the community or in the hospital. Core functionality is complete transparency across interfaces. I'm not making the assumption that there should be an independent system, that would be developed because I think we'd be missing something there. In fact, they're already existing prescribing systems that allow for medication reconciliation. Ideally, they should push a national agenda for a complete overhaul of hospital pharmacy and national prescribing systems.”*

[Interviewee 8]

#### 5.2.5.5. Accessibility and integration

Interviewees agreed that while integration and interoperability is the ideal, accessibility to ambulatory records and medication records is the first step.

*“It always struck me in terms of our work that there has to be a better way at doing this in terms of the sharing of information and some degree of traceability.”*

[Interviewee 1]

*“Yes, exactly so accessibility. I think for the electronic health record I think it's a stepping stone. So, if you just had a platform, your NIMIS and your MedLIS and Maternity and Newborn Clinical Management System and you have your electronic referrals etc If you have all of these on the one platform initially. The only thing is it wouldn't be integrated but it would be easily accessible which is important. That is key. Obviously, integration would be ideal because that's data integration. It's just much more comprehensive. But accessibility is a stepping stone and it's also very important as well. But the ideal would be integration. But we have to start with baby steps, so access is key.”*

[Interviewee 4]

*“My view of it, is that in the vast majority of cases, if the information was there it would be done perfectly. The mistakes happen because, at every step of the way, there is stuff setup to make it not work. it's not like you need a system there to auto populate my electronic kardex with the PCRS data. I mean that would be great, but it's actually not necessary to fix the problem. All you need is to be able to see the information.”*

[Interviewee 5]

## 5.2.6. Strategy

### 5.2.6.1. Interprofessional collaboration

There is a unanimous desire for interprofessional collaboration and an acknowledgement of the importance of ‘buy-in’.

*“See how it impacts on the projects that are underway already. I suppose as well as spreading the information among our pharmacy colleagues and disseminating the information through pharmacy meetings, the eHealth community, the medics and suppliers of the software.”*

[Interviewee 2]

*“I think that's part of the issue though really isn't it, you will have an angle on it, I'll have an angle on it, the community pharmacist will have an angle on it, the Physicians in the hospital will have an angle on it, the patient themselves will have an angle on it. And I think that's one of the things that was highlighted to me. To some extent a good med rec tool will need to be all things to all people. I guess one of the challenges is, how many of the interested parties do you need to involve.”*

[Interviewee 3]

*“And then the most important thing is that you get everybody included in the development. Well not everybody, because in a way if you have too many nothing gets done. But key people. So key people from the different sectors involved right from the beginning because then there's ownership as well and less resistance because they've been involved with the process from the beginning.”*

[Interviewee 4]

*“Trying to look at life from another person's perspective and see things in a process manner rather than just from what your own job is.”*

[Interviewee 7]

*“Clearly setting out the workflow as the people that are going to be doing it on the ground need to be involved. And it can't be nominal representation. The majority of the time if it's going to be pharmacist going to use this or if it's going to be nurses or medical staff. You need NCHD's, ward nursing staff, ward pharmacists, not the person that's doing the PhD, not the project manager. You need the people that are going to be dealing with it, on a day-to-day basis involved.”*

[Interviewee 10]

#### 5.2.6.2. Patient focused benefits

The importance of acknowledging the patient benefits was expressed by some of those interviewed.

*“It's just so important to promote in a language that is patient focused but that ticks the boxes in terms of the stakeholders. There are four dimensions, and there's an order to them;*

- 1. safety*
- 2. flow*
- 3. quality*
- 4. productivity or value*

*A key thing is to put safety first. But to find the economic argument for the fourth dimension which will convince the accountant to put safety first.”*

[Interviewee 8]

#### 5.2.6.2. Department of Health and eHealth Ireland

Engaging the Department of Health and the eHealth Ireland group was seen as viable strategy to progress the agenda of e-Med Rec.

*“Within an organisation groups like the drugs and therapeutics committee, quality and safety committee, having standing agenda items around the issues you're trying to resolve and under those agenda items- eHealth, eHealth, eHealth- gets mentioned at infinitum to build the case.”*

[Interviewee 10]

*“Looking at an approach to developing the system and using the backing of eHealth Ireland, the national approach to eHealth which would mean we have national systems to support that.”*

[Interviewee 9]

#### 5.2.6.3. Health Information and Quality Authority (HIQA)

HIQA was presented as a very strong enabler to drive change and development of e-Med Rec.

*“Another strategy is to develop it as a centre of excellence. Develop it and bring it forward and let other places use it in their own way. it's probably the best strategy. And then you get HIQA in to look at this, look what we have, and then they champion it. And then they say to everywhere else they need to get on board, we have the solution.”*

[Interviewee 6]



*“I found is that HIQA have been really a useful tool for driving change and within the Irish medication safety network. So, what you produce, that should go to HIQA, and that might influence a document or a policy brief from them around updating our medication reconciliation work as I know that they have previous work done on it. So, this can help bring it into a more modern era.”*

[Interviewee 10]

#### 5.4. Conclusion

This chapter presented the results from the semi-structured interviews. The literature previously discussed and documented international experience in the development of prototypes and implementation strategies. This chapter has presented what key informants view as functionality that is desirable for an Irish setting. Strategy ideas were also shared that would be applicable to Irish work settings and Irish government policies. The next chapter will contain an evaluation and discussion of the results.

## Chapter 6. Evaluation, Discussion and Conclusion

### 6.1. Introduction

This chapter will discuss the remaining results from the research. It will present the authors interpretation of the analysis of the findings of this study against the backdrop of the literature and how this is relevant to an Irish setting. Based on what was found in chapters 2,3 and 5, the author has synthesized a proposed a Gold Standard list of functionality requirements and graded classification system for e-Med Rec tools.

### 6.2. Proposed Gold Standard list of functionality requirements for an e-Med Rec tool.

Figure 19 is a development of figure 17. It outlines the contributing factors to the synthesis of the proposed list of functionality requirements for an e-Med Rec tool.

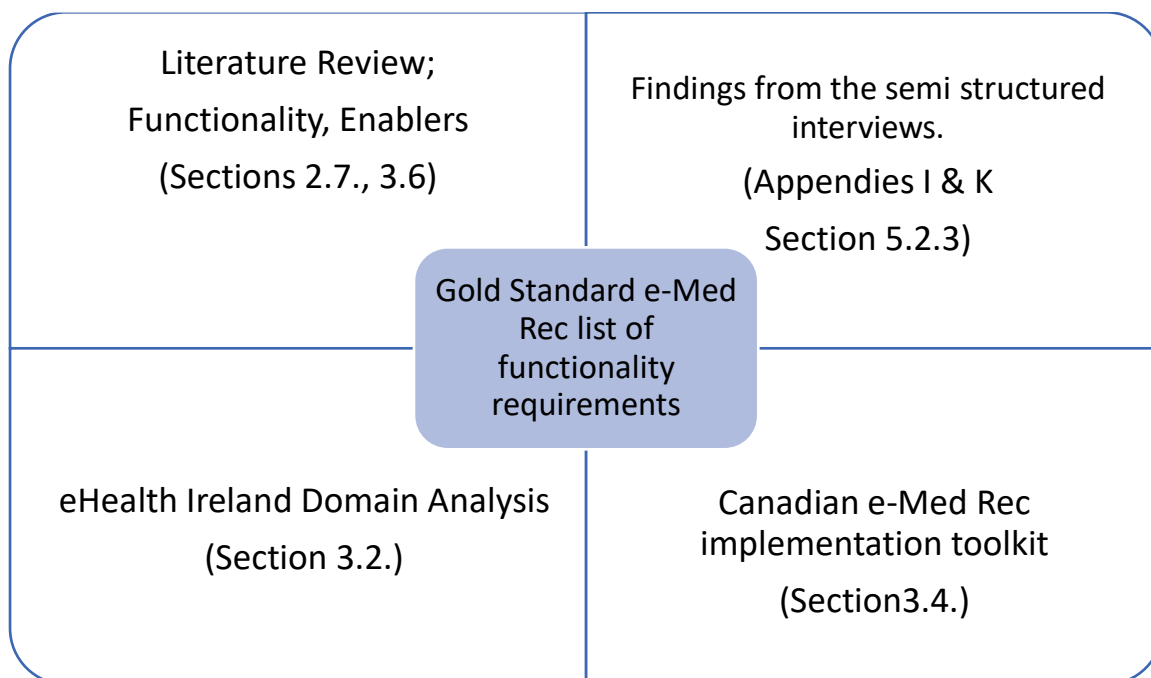


Figure 19. Evidence used for synthesis of Gold Standard e-Med Rec prototype

Table 7. Proposed Gold Standard e-Med Rec list of functionality requirements.

<b>Ideal Functionality of e-Med Rec</b>
<b>Features</b>
A. Displays current medication and Best Possible Medication History (BPMH) side by side to facilitate comparison
B. Allows filters for sorting medicines e.g. by therapeutic class, most recently prescribed, ordering physician, discontinued medications etc.
C. Displays medication history (current and discontinued medication) in a timeline
D. Allows modification of medicines i.e. continue, discontinue, hold
E. Possibility to link with Computerized Physician Order Entry (CPOE)
F. Possibility for Clinical Decision Support
G. Task List to be generated after med rec completion
H. Hierarchy of Interactive alerts/reminders
I. Patient accessibility
J. Facility to document 'who manages the medicines' in the pre-admission setting
K. Access to any documented information from EPR's regarding medication side effects, allergies and intolerances
L. Ability to be operated on tablet and desktop
<b>Access to electronic sources of pre-admission information</b>
A. Access to a Summary Care Record which would encompass data from Community Pharmacy, GP and public and private hospitals and specialist settings such as psychiatry service
<b>Comparison of various sources of pre-admission medication information</b>
A. Identification of source(s) of information
B. Display of dates prescribed as appropriate for each source
C. Highlights differences in doses, frequencies, routes and formulations for each medicine
D. Allows sorting of medication by name, class, date and source
<b>Ability to show patient compliance with medication</b>
A. Calculation of medication possession ratio based on pharmacy fill and refill data.
B. Access to any documented information from EPR's regarding medication compliance
<b>Documentation of the Best Possible Medication History (BPMH)</b>
A. Ability to create the BPMH separate to the sources on which it is based
B. Ability to pull medication from electronic sources into the BPMH

C. Ability to add new medications into the BPMH based on other (non-electronic) sources of information
D. Ability to update the BPMH at any time during hospitalization.
E. Ability to document the quality of the BPMH (from a list of choices) in the opinion of the history taker.
F. Ability to document the sources of information used to create the BPMH from a list of coded choices.
G. Audit trail to document changes to the BPMH made during the course of the hospitalization including when and by whom (person and role)
<b>Verification</b>
A. Facility to sign off that a BPMH s ready for reconciliation
B. Ability to document verification of a BPMH by a second clinician
<b>Facilitation of admission reconciliation</b>
A. Documentation of planned action on admission for each medication on the BPMH; continue, discontinue, hold, substitute.
B. Ability to capture and flag differences between BPMH and prescribed medication
C. Document intentional reasons for changes between the BPMH and prescribed medication
D. Modify prescription orders as needed to resolve unintentional discrepancies
<b>Facilitation of discharge reconciliation</b>
A. Compare and flag differences between the BPMH and discharge prescription
B. Document reasons for intentional changes made to medications
C. Ability to add new medications if necessary
D. Ability to run decision support on discharge medication regiment (e.g. for duplicate therapy)
E. Ability to transmit electronic prescription to community pharmacy
F. Ability to transmit electronic prescription to GP and other specialist settings involved in the care of the patient
G. Ability to print and sign prescription at discharge
H. Ability to print patients own copy of discharge medication presented in patient friendly language
<b>Tools to facilitate compliance with Med Rec process</b>
A. Ability to track timing of the BPMH documentation relative to the time of admission
B. Provide alerts, reminders if BPMH or reconciliation has not been completed in a set timeframe
C. Ability to generate reports of all patients who require medication reconciliation
<b>Tools to identify high-risk patients</b>
A. Automatically identify and generate a report of patients at high-risk for medication error based on the number and/or classes of medication in the BPMH and/or based on the number of changes from pre-admission to discharge medications so that further action can be taken.

(Table 7 continued.)

### 6.3. Proposed classification of electronic Med Rec Systems

Figure 20 is a development of figure 18 which has sign-posts towards the corresponding sections that contain the evidence which led to the development of figure 21, the proposed graded classification of e-Med Rec tools. Table 8 outlines the rationale for moving from one level to another. Moving to the next level involves increased benefits as outlined in table 2. Achieving the highest level or gold standard e-Med Rec status for an Irish setting is very much dependent on eHealth enablers being fully operational.

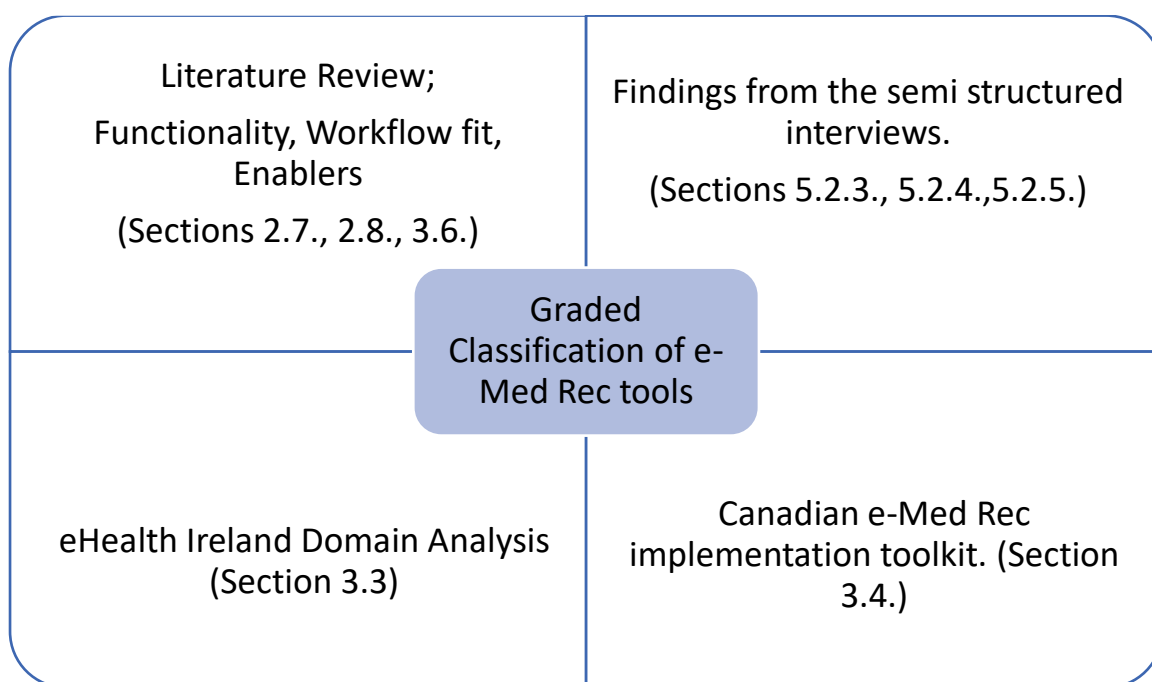


Figure 20. Synthesis of research that resulted in the development of proposed graded classification of e-Med Rec tools

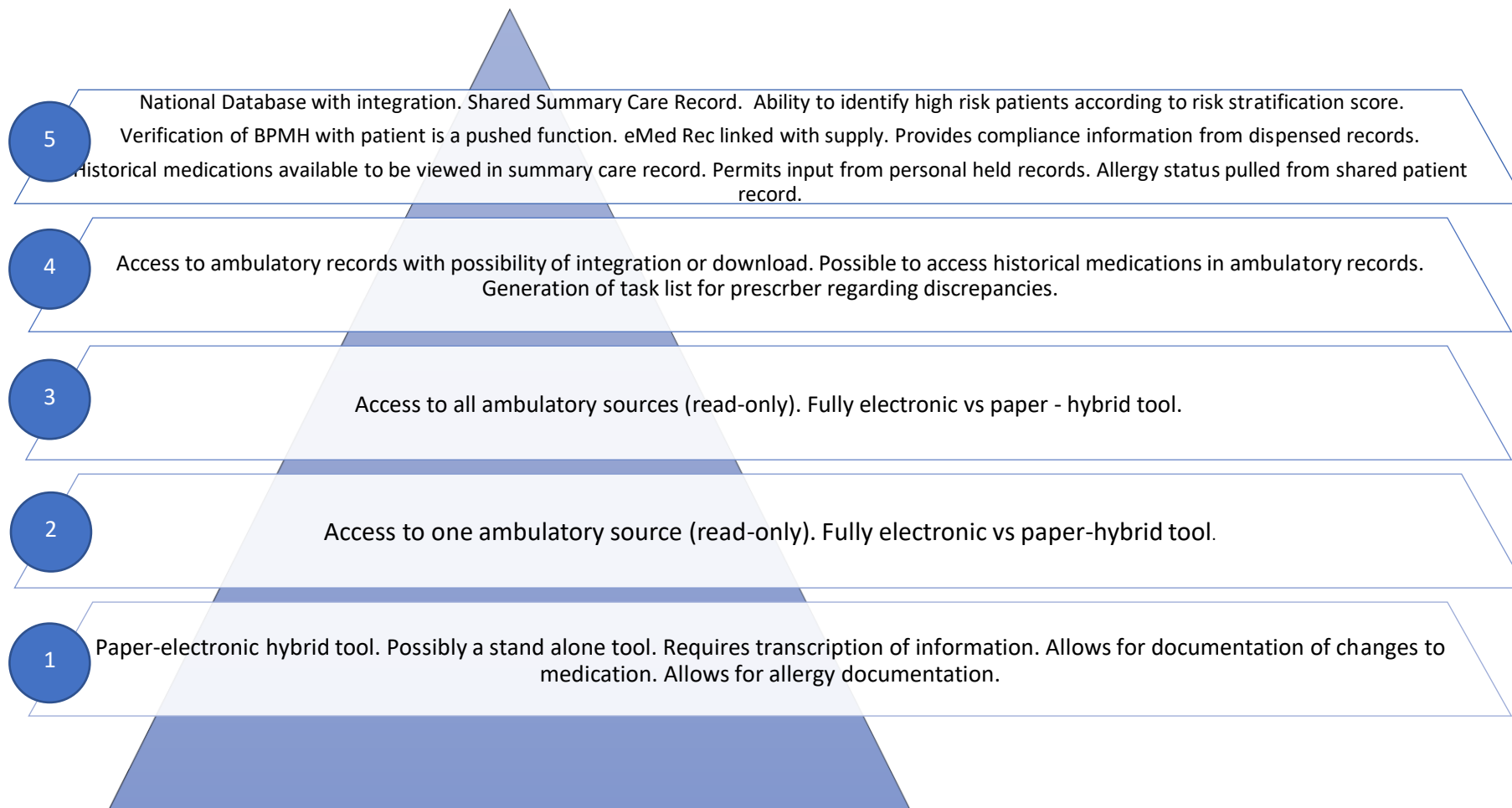


Figure 21. Proposed classification of e-Med Rec tools

Table 8. Explanation of Different Levels of Classification of e-Med Rec solutions

	<b>Benefits</b> (Section 2.5.1)	<b>Functionality</b> (Section 6.2)	<b>Enablers</b> (section 3.6)
<u>Level 5</u>	<p>Increased efficiency of Med Rec process →</p> <p>Improved compliance of process through use of alerts →</p> <p>Integration with CPOE to improve the medication ordering process →</p> <p>Reduced unintended discrepancies at points of transfer →</p> <p>Access to medication information →</p>	<p>Helps streamline pharmacy workload</p> <p>Forcing verification with patient</p> <p>Linked with CPOE</p> <p>Linked with central medication repository</p> <p>Access to pharmacy refill data</p>	<p>Integration</p> <p>IHI</p> <p>National medicinal catalogue</p> <p>Accessibility</p> <p>Central Medicines Repository</p>
<u>Level 4</u>	<p>Increased efficiency of Med Rec process →</p> <p>Reduced unintended discrepancies →</p>	<p>Accessibility in a timely manner to prescribed and dispensed information</p> <p>Eliminating need for transcription</p>	<p>Integration</p> <p>IHI</p>
<u>Level 3</u>	<p>Increased efficiency of Med Rec process</p> <p>Improved electronic access to 2 sources of PAML's</p>	<p>Accessibility in a timely manner to prescribed and dispensed information</p>	<p>Accessibility</p>
<u>Level 2</u>	<p>Increased efficiency of Med Rec process</p> <p>Improved electronic access to one source for PAML's</p>	<p>Accessibility in a timely manner to a degree of dispensed data</p>	<p>Accessibility</p>
<u>Level 1</u>	<p>Process is being undertaken</p>		

## 6.4. Discussion

The literature provides a wealth of information on international experience of e-Med Rec solutions. The interviews conducted as part of this research enabled the author to tailor the results to an Irish setting in view of the country's health system and the unique set of barriers and issues to be overcome from an eHealth perspective.

The functionality requirements for an ideal e-Med Rec tool were generally consistent with international experience and recommendations. Contrary to documented experience in the US, forced compliance/mandating the process was not seen as favourable in an Irish setting. This may be due to the level of advancement achieved in the US in terms of technology and the relative infancy of electronic systems in the current Irish setting. Accessibility to information was agreed to be essential and a precursor to larger scale integration of EPR's. Ultimately what is desired is 'one single source of truth'. The introduction of a central medicines repository was envisaged to be the ideal solution to the issue around the existence of multiple medication lists. While Ireland has a significant journey until full scale interoperability is achieved and it is yet unknown as to when the proposed Summary Care Record will be introduced, access to ambulatory medication records was agreed as a key enabler to the functioning of an e-Med Rec tool in the interim.

For Gold Standard Med Rec, the patient needs to be involved in the verification of the medicines list order to obtain the BPMH. Active patient involvement in the e-Med Rec process has emerged as an element that could possibly be a future consideration in the development of such a tool. This is in line with the aspirations for patient empowerment as alluded to in the HSE 2018 National Service Plan. Active involvement with the e-Med Rec process was suggested through patient access through a defined portal and provision of their own self-reported list of medications. Another suggestion was the possibility to be invited to comment on medication discrepancies between lists and advise on their adherence. Opinions on the extent of patient involvement are currently divided. This is understandable due to the novel concept of such a feature.



*'Standardise, incentivise and computerize'[Interviewee 10].*

Consistent with the literature it was commonly agreed that automating the process would help standardize the process. Interestingly contrary to the variability in the practice there did not seem to be a desire for the customization of tools to fit the institution. It is evident from the literature that a clear governance is required to oversee the standardisation and ensure compliance with these standards. The need for collaboration around this area was recommended by HIQA in its 2018 Medication Safety Monitoring report and this was reinforced by the key informants. Med Rec is a process that requires agreement and standardisation on a national scale. An electronic solution should follow this and requires intra- and multi-disciplinary collaboration and buy-in. There was strong agreement that for an Irish setting this initiative should be pharmacy-led. Pharmacists need to collaborate and take ownership of this process and be the driving force that is required to put this onto key stakeholder agendas.

Consistent with the literature, key stakeholders identified that there is a clear need for leadership. Leadership on a local and national level is required to endorse the process and promote e-Med Rec. HIQA, the HSE, eHealth Ireland and clinical champions are all key players in the success of this project. Engagement from policy makers is fundamental for this initiative to make it onto local agendas and the national service plan. eHealth strategies are already being discussed and planned on a national level and it is important to put this electronic process onto the agenda at this stage in the planning. Table 9 shows a tabulation of suggested implications of this work for relevant stakeholders.

Table 9. Implications of study for key stakeholders in the Irish setting as proposed by the author

<b>Key stakeholders</b>	<b>Main area of influence</b>	<b>Organisations/ professional groups</b>	<b>Implications of research</b>
Research	Functionality	eHealth Educational institutions	Further develop and validate the list of functionality requirements. Build and pilot prototype.
Clinical champions	Work-flow fit	Pharmacists Medical consultants Clinical Directors Nurse Practice Development GP's	Endorsement of compliance with Med Rec process on a local level. Use of graded classification to assess 'as is' versus 'to-be' status in terms of e-Med Rec. Formation of special interest groups to work towards agreement on standardizing and formalizing the Med Rec process. Multidisciplinary collaboration on a local level to assess how best to incorporate Med Rec into the workflow.
Government organisations	Enablers	eHealth Ireland	Use of graded classification and list of functionality requirements to facilitate necessary IT development and information accessibility to progress towards gold-standard e-Med Rec
Policy makers	Strategy	Senior management HIQA HSE eHealth Ireland	Standardization of process. Set standards and targets. Acknowledgement of the importance of an e-Med Rec capture in the development of e-Medication Management Systems.

There are key eHealth enablers that are required for a gold standard e-Med Rec tool. However, there was a unanimous agreement among interviewees that while we are far from achieving and installing the ideal e-Med Rec solution, work can commence around standardisation and use of institutional resources already in place. The proposed graded classification presented in this research allows for an incremental approach to the ideal solution. This may be interpreted as suggestions of subsequent steps which may be addressed by eHealth Ireland to facilitate the advancement of this process.

The work that has been completed through this research are the first steps towards a working prototype which in itself could be seen as an enabler to putting e-Med Rec onto National agendas. Support from key stakeholders alongside an amalgamation of expertise and innovation could further the journey of an electronic standardised solution. This is not a process that will be corrected first time but will require a certain amount of iterations to arrive at the ideal solution.

#### 6.5. Strengths and limitations of the study.

A large degree of information was primarily gathered from the literature. The recurring themes helped direct the formulation of the resulting topic guide. The availability of the Canadian 'Paper to Electronic Med Rec Implementation toolkit' also helped reaffirm the structure and content of the topic guide used for the semi-structured interviews. The author's experience of Med Rec was also helpful in understanding the technicalities and intricacies of the process. Through this study, engagement has begun with key stakeholders in the semi-structured interviews. This study has created awareness of this knowledge gap and has evoked interest from the interviewees.

Time was a limiting factor for the scope of this study. Another limitation of this study was the lack of inclusion of the patient's perspective in the interview process.

## 6.6. Future work and research

This research is intended to commence work around the consideration of e-Med Rec for an Irish setting. It is intended that this process be presented to and analysed by a variety of end users in an iterative fashion to obtain the best fit solution. Figure 22 depicts the investigations that have been commenced in this research and the proposed future work through use of knowledge moments.

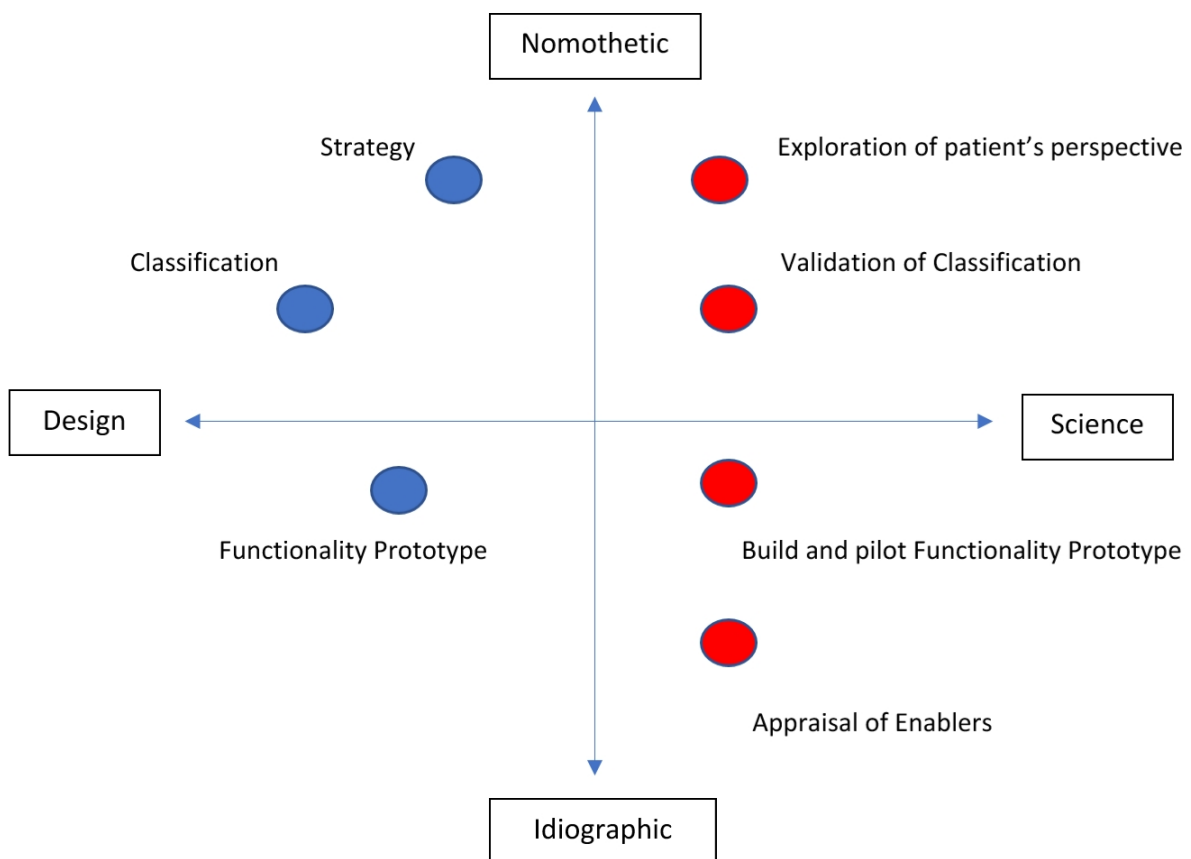


Figure 22. Work commenced in the study (shown in blue) and some proposed future work (shown in red) as depicted by the genres of inquiry framework for design-science (Baskerville, Kaul and Storey, 2015).

Other future work could involve:

- Critically appraising enablers and current systems readiness for the facilitation of e-Med Rec.
- Critical analysis could lead onto an analysis of technologies to enable e-Med Rec e.g. blockchain technology.
- Piloting a prototype with end users and engaging in the iterative process of refining the prototype with the aid of end user feedback.
- Validation the proposed graded classification of e-Med Rec tools.
- Involve a patient's perspective on the e-Med Rec tool. Possible engagement with the Irish Platform for Patient Organisations, Science and Industry (IPPOSI).
- An exploration into governance structures which should be in place to support e-Med Rec.

## 6.7. Conclusion

The findings from this research are mostly consistent with the literature. Among key stakeholders there is a desire for a standardised, simple system for e-Med Rec. It should ideally work itself in with existing systems, be designed to allow for future integration and be compatible with enablers such as the national medicinal catalogue and IHI when they become available. The success of this project requires support from clinical leaders and government bodies. Work around the standardisation and agreement on a universally acceptable design should start now. As an interviewee stated:

*“It will be 10 years before the last hospital gets their electronic health record at least. And how much harm will happen, as a result of poor medication reconciliation before then? “*

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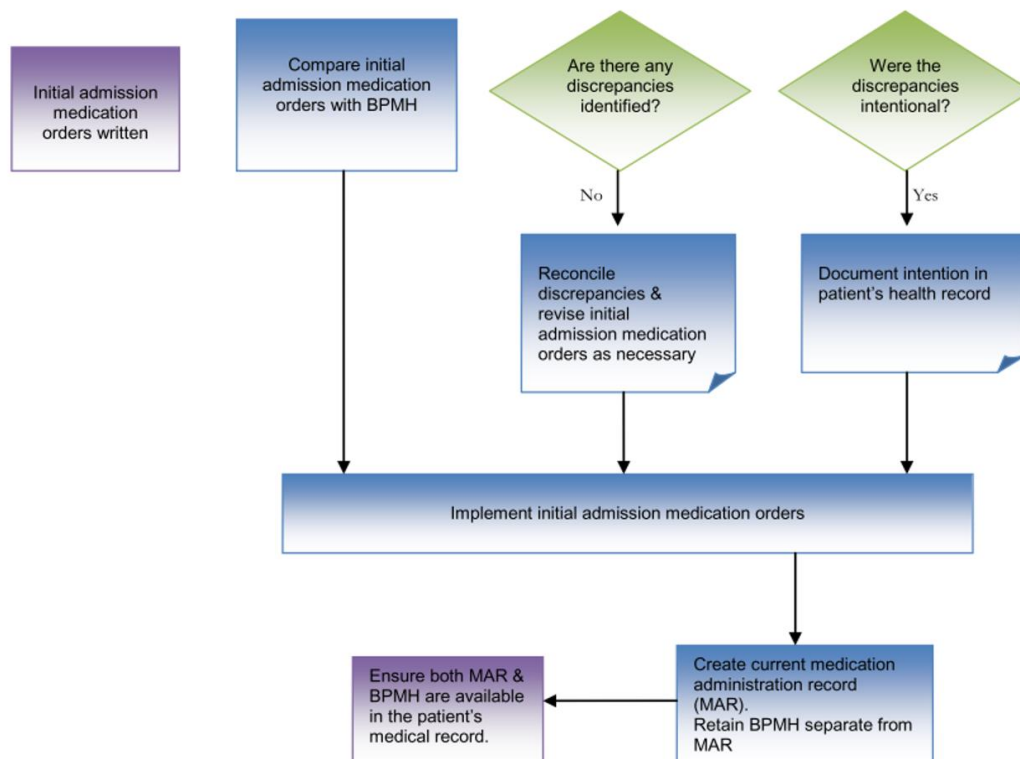
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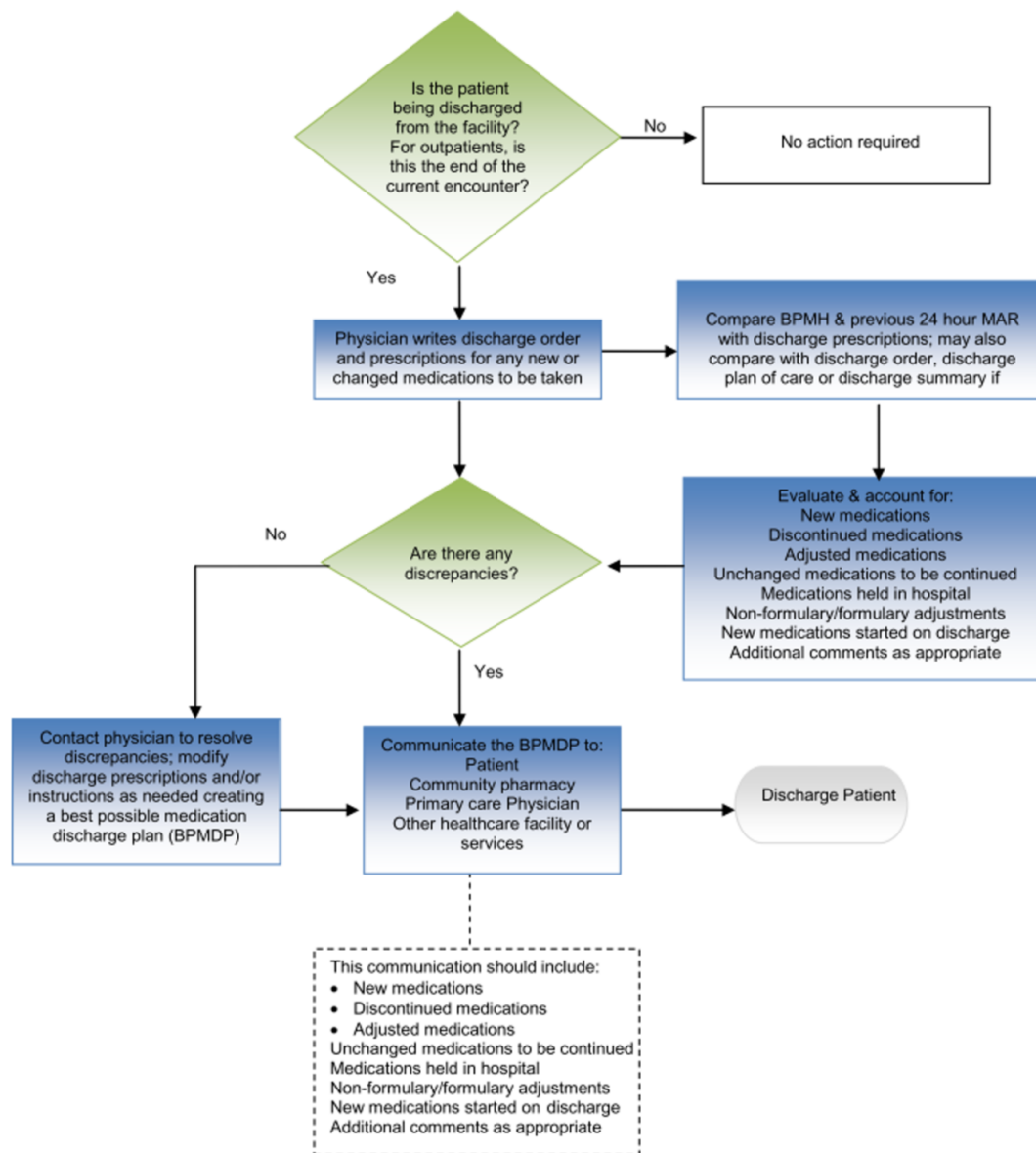
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## Appendices

Appendix A: Admission Medication Reconciliation Process (World Health Organisation, 2007).



Appendix B: Discharge Medication Reconciliation Process (World Health Organisation, 2007).







Appendix D: Naas General Hospital Discharge Prescription Pilot Sample.



Naas General Hospital, Kildare

# PRESCRIPTION

Naas General Hospital, Kildare



NAAS, CO. KILDARE Main Reception: 045 849500

Patient #EC051101	PRESCRIPTION NUMBER NGH-334	DATE: 22/11/2016
	ALLERGIES / SENSITIVITIES: Other : Morphine	
	DOCTOR NAME (block capitals): DOCTOR'S SIGNATURE: REGISTRATION NUMBER: PHARMACIST NAME: <input type="text"/> PHARMACIST SIGNATURE:	

CURRENT MEDICATION FOR DISPENSING					
DRUG	DOSE	FREQUENCY	FORM	ROUTE	DURATION (IF NOT ONGOING)
RANOLAZINE HYDROCHLORIDE	375mg	BD	tablets	PO	
PANTOPRAZOLE	20mg	Once daily	tablets	PO	
AZATHIOPRINE	50mg	BD	tablets	PO	
PYRIDOSTIGMINE BROMIDE	60mg	TID	tablets	PO	
ESCITALOPRAM	15mg	Once daily	tablets	PO	
FRUMIL LOW STRENGTH	20mg/2.5mg	Once daily	Tablet	PO	
ZOLPIDEM	5mg	Once daily	tablets	PO	
MIRABEGRON	25mg	Once daily	Tablet	PO	
HYOSCINE BUTYLBROMIDE	10mg	TDS PRN	tablets	PO	
PREDNISOLONE	12.5mg	Once daily	Tablet	PO	
PARACETAMOL	500mg	ii QDS PRN	tablets	PO	
MYCOSTATIN ORAL SUSPENS 30ML	100000units/mL	1ml QDS	oral suspension	PO	
SALBUTAMOL	100mcg/dose	2 puffs QDS PRN	inhaler	Inhaled	
PROLIA PREFILLED SYRINGE 6	60mg/mL	every 6 months	prefilled syringe	SC	
DESUNIN	1600units	Once daily	tablet	PO	
RIVAROXABAN	15mg	15mg BD for 21days	tablets	PO	Date: 20/01/2016 To: 02/02/2016
RIVAROXABAN	20mg	20mg OD after three weeks of 15mg BD completed	tablets	PO	Date: 03/02/2016
CO-AMOXICLAV	625mg	TID	tablets	PO	Date: 27/01/2016 To: 03/02/2016
ENSURE PLUS JUICE	220ml	BD	liquid	PO	

August 2016 Version 6



Naas General Hospital, Kildare

# PRESCRIPTION

Naas General Hospital, Kildare



NAAS, CO. KILDARE Main Reception: 045 849500

Patient #EC051101	PREScription NUMBER NGH-335	DATE: 22/11/2016
	ALLERGIES / SENSITIVITIES: Other : Morphine	
	DOCTOR NAME (block capitals): DOCTOR'S SIGNATURE: REGISTRATION NUMBER: PHARMACIST NAME: <input type="text"/> PHARMACIST SIGNATURE:	

For Information only do not dispense		
MEDICATION CHANGED OR DISCONTINUED	ACTION	INTERVENTION DETAIL
ASPIRIN	Held	Aspirin therapy to be stopped for the duration of DVT treatment. To recommence after Rivaroxaban discontinued.
CALCICHEW D3 FORTE	Stop	Stopped and switched to desunin 100 units OD. Vitamin D level low.
FORTISIP	Stop	Changed to Ensure Plus Juice by dietician
MYCOSTATIN ORAL SUSPENS 30ML	Start	Newly started for oral care
SALBUTAMOL	Start	SOB
PROLIA PREFILLED SYRINGE 6	Start	Check Vitamin D levels before administering.
DESUNIN	Start	Newly started on this admission. Vitamin D level low.
RIVAROXABAN	Start	Newly started for the treatment and further prevention of DVT. Patient to take 15mg BD for 3weeks then 20mg OD thereafter. (commenced on 20/1/16) FBC, LFTs, U&Es to be checked within 3months of commencing Rivaroxaban.
RIVAROXABAN	Start	Newly started for the treatment and further prevention of DVT. Patient to take 15mg BD for 3weeks then 20mg OD thereafter. Commenced on 20/1/2016. FBC, LFTs, U&Es to be checked within 3months of commencing Rivaroxaban.
CO-AMOXICLAV	Start	7 day antibiotic course for UTI
ENSURE PLUS JUICE	Start	Changed from Fortisip by dietician
IBUPROFEN	Stop	Ibuprofen stopped as patient commenced on NOAC. Increased risk of bleeding with NSAID and NOAC.

August 2016 Version 6

## Appendix E: Stages of HIMSS Analytics EMR Adoption Model (EMRAM)(Himss and Emram, 2017).

### The stages of the model are as follows:

- Stage 0:** The organization has not installed all of the three key ancillary department systems (laboratory, pharmacy, and radiology).
- Stage 1:** All three major ancillary clinical systems are installed (i.e., pharmacy, laboratory, and radiology). A full complement of radiology and cardiology PACS systems provides medical images to physicians via an intranet and displaces all film-based images. Patient-centric storage of non-DICOM images is also available.
- Stage 2:** Major ancillary clinical systems are enabled with internal interoperability feeding data to a single clinical data repository (CDR) or fully integrated data stores that provide seamless clinician access from a single user interface for reviewing all orders, results, and radiology and cardiology images. The CDR/data stores contain a controlled medical vocabulary and order verification is supported by a clinical decision support (CDS) rules engine for rudimentary conflict checking. Information from document imaging systems may be linked to the CDR at this stage. Basic security policies and capabilities addressing physical access, acceptable use, mobile security, encryption, antivirus/anti-malware, and data destruction.
- Stage 3:** 50 percent of nursing/allied health professional documentation (e.g., vital signs, flowsheets, nursing notes, nursing tasks, care plans) is implemented and integrated with the CDR (hospital defines formula). Capability must be in use in the ED, but ED is excluded from 50% rule. The Electronic Medication Administration Record application (eMAR) is implemented. Role-based access control (RBAC) is implemented.
- Stage 4:** 50 percent of all medical orders are placed using Computerized Practitioner Order Entry (CPOE) by any clinician licensed to create orders. CPOE is supported by a clinical decision support (CDS) rules engine for rudimentary conflict checking, and orders are added to the nursing and CDR environment. CPOE is in use in the Emergency Department, but not counted in the 50% rule. Nursing/allied health professional documentation has reached 90% (excluding the ED). Where publicly available, clinicians have access to a national or regional patient database to support decision making (e.g., medications, images, immunizations, lab results, etc.). During EMR downtimes, clinicians have access to patient allergies, problem/diagnosis list, medications, and lab results. Network intrusion detection system in place to detect possible network intrusions. Nurses are supported by a second level of CDS capabilities related to evidence-based medicine protocols (e.g., risk assessment scores trigger recommended nursing tasks).
- Stage 5:** Full physician documentation (e.g., progress notes, consult notes, discharge summaries, problem/diagnosis list, etc.) with structured templates and discrete data is implemented for at least 50 percent of the hospital. Capability must be in use in the ED, but ED is excluded from 50% rule. Hospital can track and report on the timeliness of nurse order/task completion. Intrusion prevention system is in use to not only detect possible intrusions, but also prevent intrusions. Hospital-owned portable devices are recognized and properly authorized to operate on the network, and can be wiped remotely if lost or stolen.
- Stage 6:** Technology is used to achieve a closed-loop process for administering medications, blood products, and human milk, and for blood specimen collection and tracking. These closed-loop processes are fully implemented in 50 percent of the hospital. Capability must be in use in the ED, but ED is excluded from 50% rule. The eMAR and technology in use are implemented and integrated with CPOE, pharmacy, and laboratory systems to maximize safe point-of-care processes and results. A more advanced level of CDS provides for the "five rights" of medication administration and other 'rights' for blood product, and human milk administrations and blood specimen processing. At least one example of a more advanced level of CDS provides guidance triggered by physician documentation related to protocols and outcomes in the form of variance and compliance alerts (e.g., VTE risk assessment triggers the appropriate VTE protocol recommendation). Mobile/portable device security policy and practices are applied to user-owned devices. Hospital conducts annual security risk assessments and report is provided to a governing authority for action.
- Stage 7:** The hospital no longer uses paper charts to deliver and manage patient care and has a mixture of discrete data, document images, and medical images within its EMR environment. Data warehousing is being used to analyze patterns of clinical data to improve quality of care, patient safety, and care delivery efficiency. Clinical information can be readily shared via standardized electronic transactions (i.e., CCD) with all entities that are authorized to treat the patient, or a health information exchange (i.e., other non-associated hospitals, outpatient clinics, sub-acute environments, employers, payers and patients in a data sharing environment). The hospital demonstrates summary data continuity for all hospital services (e.g., inpatient, outpatient, ED, and with any owned or managed outpatient clinics). Physician documentation and CPOE has reached 90% (excluding the ED), and the closed-loop processes have reached 95% (excluding the ED).

Appendix F: Table Summary of Literature.

<b>Authors</b>	<b>Study</b>	<b>Functionality</b>	<b>Workflow fit</b>	<b>Enablers</b>
(Agrawal, 2009)	Review	-	-	-
(Agrawal, Wu and Khachewatsky, 2007)	Study	Yes	Yes	Yes
(Agrawal and Wu, 2009)	Study	Yes	Yes	Yes
(Almanasreh, Moles and Chen, 2016)	Systematic literature review	-	-	-
(Bails <i>et al.</i> , 2008)	Study	Yes	Yes	Yes
(Bassi, Lau and Bardal, 2010)	Scoping review	Yes	Yes	Yes
(Cadwallader <i>et al.</i> , 2013)	Study	Yes	Yes	Yes
(Elysee, Herrin and Horwitz, 2017)	Study	-	-	Yes
(Hasan <i>et al.</i> , 2011)	Study	Yes	-	-
(Helene Tarp, Lili Worre Høpfner Jensen, Nikolaj Krabbe Jepsen, Henrik Majkjær Marquart, Mads Clausen, Nina Aagaard Madsen, 2017)	Study	Yes	Yes	Yes
(Jonathan D Hron <i>et al.</i> , 2015)	Study	Yes	Yes	-
(Lawrence <i>et al.</i> , 2015)	Study	Yes	-	-
(Lee, 2013)	Study	Yes	-	-
(Lesselroth <i>et al.</i> , 2017)	Study	Yes	Yes	-
(Marien, Krug and Spinewine, 2017)	Systematic Review	Yes	Yes	-
(Markowitz <i>et al.</i> , 2011)	Study	Yes	-	-
(Ministry of Health, 2015)	Government report	-	-	Yes
(Monkman <i>et al.</i> , 2013)	Scoping Review	-	Yes	Yes
(Munck <i>et al.</i> , 2014)	Study	-	Yes	Yes
(Poon <i>et al.</i> , 2006)	Pilot study	Yes	Yes	Yes
(Sardaneh <i>et al.</i> , 2017)	Study	Yes	-	-
(Schnipper <i>et al.</i> , 2009)	Study	Yes	Yes	Yes
(Schnipper <i>et al.</i> , 2011)	Study			
(Turchin <i>et al.</i> , 2007)	Study	Yes	-	-
(Turchin <i>et al.</i> , 2008)	Study	Yes	Yes	Yes
(Turchin <i>et al.</i> , 2011)	Study	Yes	Yes	-
(Varkey <i>et al.</i> , 2007)	Study	-	Yes	-
(White <i>et al.</i> , 2011)	Study	Yes	Yes	-
(World Health Organisation, 2007)	Report	-	Yes	-
(Zhu and Cimino, 2015)	Report	Yes	Yes	-
(Ziminski <i>et al.</i> , 2012)	Report	Yes	-	Yes

Appendix G: Interview Topic Guide.

Core Questions	Probe Questions
<b>Core Functionality</b>	
1. What are the features that should be contained in an electronic medication reconciliation tool?  2. What are the most important in your opinion?	Would electronic prescribing have to be fully functional in the institution to facilitate this? Would you like to elaborate on this point?  Would you consider a standalone electronic medication reconciliation tool to be a reasonable intermediate solution?
<b>Workflow fit</b>	
3. [Medication reconciliation is defined and performed differently across various institutions.] If a gold standard electronic solution was introduced, how could this be promoted? (a) On a local level? (b) On a national level?	Do you think that it is essential for pharmacists to be involved at the verification stage? (to ensure best practice)  In an institution where there is no pharmacist-led med rec process, do you think that an electronic solution could help promote awareness of and compliance with, this process among medical and nursing staff?  Do you think this process should be mandated?
<b>Essential Enablers</b>	
4. What are the essential enablers to support a gold standard electronic med rec tool in an Irish setting?	
<b>Strategy</b>	
5. Have you any ideas on how to make this a priority on the eHealth Ireland strategy?	
6. Any additional comments?	

Appendix H: Interview functionality prompt.

<b>Ideal Functionality of e-Med Rec</b>	
<b>Features</b>	<b>Comments</b>
M. Displays current medication and Best Possible Medication History (BPMH) side by side to facilitate comparison	
N. Allows filters for sorting medicines e.g. by therapeutic class, most recently prescribed, ordering physician, discontinued medications etc.	
O. Displays medication history (current and discontinued medication) in a timeline	
P. Allows modification of medicines i.e. continue, discontinue, hold	
Q. Is linked with Computerized Physician Order Entry (CPOE)	
R. Having Med Rec as a Mandatory function	
S. Possibility for Clinical Decision Support	
T. Customization to specific institution	
U. Task List to be generated after med rec completion	
V. Interactive alerts/reminders	
<b>Access to electronic sources of pre-admission information</b>	
A. Community Pharmacy data	
B. GP data	
C. Discharge medication from recent hospitalizations at the same healthcare institution	
D. Medications from personal health records	
E. Specialist services i.e. psychiatry services	
F. Private hospital records	
<b>Comparison of various sources of pre-admission medication information</b>	
E. Identification of source(s) of information	
F. Display of dates prescribed as appropriate for each source	
G. Highlights differences in doses, frequencies, routes and formulations for each medicine	
H. Allows sorting of medication by name, class, date and source	
<b>Ability to show patient compliance with medication</b>	
C. Calculation of medication possession ratio based on pharmacy fill and refill data.	
D. Access to any documented information from EPR's regarding medication compliance, side effects, allergies or intolerances	
<b>Documentation of the Best Possible Medication History (BPMH)</b>	
H. Ability to create the BPMH separate to the sources on which it is based	
I. Ability to pull medication from electronic sources into the BPMH	

J. Ability to add new medications into the BPMH based on other (non-electronic) sources of information	
K. Ability to update the BPMH at any time during hospitalization.	
L. Ability to document the quality of the BPMH (from a list of choices) in the opinion of the history taker.	
M. Ability to document the sources of information used to create the BPMH from a list of coded choices.	
N. Audit trail to document changes to the BPMH made during the course of the hospitalization including when and by whom (person and role)	
<b>Verification</b>	
C. Facility to sign off that a BPMH is ready for reconciliation	
D. Ability to document verification of a BPMH by a second clinician	
<b>Facilitation of admission reconciliation</b>	
E. Documentation of planned action on admission for each medication on the BPMH; continue, discontinue, hold, substitute.	
F. Ability to capture and flag differences between BPMH and prescribed medication	
G. Document intentional reasons for changes between the BPMH and prescribed medication	
H. Modify prescription orders as needed to resolve unintentional discrepancies	
<b>Facilitation of discharge reconciliation</b>	
I. Compare and flag differences between the BPMH and discharge prescription	
J. Document reasons for intentional changes made to medications	
K. Ability to add new medications if necessary	
L. Ability to run decision support on discharge medication regimen (e.g. for duplicate therapy)	
M. Ability to transmit electronic prescription	
N. Ability to print and sign prescription at discharge	
<b>Tools to facilitate compliance with med rec process</b>	
D. Ability to track timing of the BPMH documentation relative to the time of admission	
E. Provide alerts, reminders and/or hard stops if BPMH or reconciliation has not been completed in a set timeframe	
F. Ability to generate reports of all patients who require medication reconciliation	
<b>Tools to identify high-risk patients</b>	
B. Automatically identify and generate a report of patients at high-risk for medication error based on the number and/or classes of medication in the BPMH and/or based on the number of changes from pre-admission to discharge medications so that further action can be taken.	



**Trinity College Dublin**

Coláiste na Tríonóide, Baile Átha Cliath

The University of Dublin

**“Towards creating a prototype for the medication reconciliation capture in electronic medication management systems”**

Dear

As part of research for an MSc in Health Informatics through The University of Dublin, Trinity College, I am currently undertaking a study on the above title. I also work as a clinical pharmacist in Naas General Hospital, Co. Kildare, Ireland.

The objectives of this qualitative research are to explore your opinions of the essential functionality required for electronic medication reconciliation capture. Your participation will help inform the development of a prototype for electronic medication reconciliation which could be considered for current and future electronic medication management systems. Taking part will involve an individual face-to-face or telephone semi-structured interview not lasting more than 45 minutes at a location and at a time that is convenient for you.

Attached are further details of the study and information regarding your participation in the interview. If you are interested in participating in this study, please return the attached consent and background questionnaire, as well as advising on a suitable time, method and place (if applicable) to conduct the interview.

If you have any questions, please do not hesitate to contact me on 0863627782 or email [ccotter@tcd.ie](mailto:ccotter@tcd.ie). Alternatively, you can contact my supervisor; Ms Gaye Stephens at [gaye.stephens@tcd.ie](mailto:gaye.stephens@tcd.ie).

Yours sincerely,

Clíodhna Cotter

M(Sc) Health Informatics Student

School of Computer Science and Statistics

The University of Dublin, Trinity College

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### Participant information sheet

**Title of the project: “Towards creating a standard for the medication reconciliation capture in electronic medication management systems”**

Before you decide to take part in this study, I kindly request you to carefully read the information provided below relating to this project. This will assist you in understanding why the research is being conducted and what it will involve. Please feel free to discuss this with others or ask me about any matters you may find unclear. Thank you for your time in reading this.

Name of the principal researcher:

Clíodhna Cotter, School of Computer Science and Statistics, Trinity College Dublin.

Email: [ccotter@tcd.ie](mailto:ccotter@tcd.ie)

Background of the research: The objectives of this qualitative research are to explore the relevance and functionality required for electronic medication reconciliation capture. Your participation will help inform the development of a prototype for electronic medication reconciliation which could be considered for current and future electronic medication management systems. This research is being conducted as part of an M(Sc) in Health Informatics through Trinity College Dublin.

Procedures of this study: Participation will involve an individual face-to-face or telephone semi-structured interview not lasting more than 45 minutes at a location and at a time that is convenient for you. With your permission, the interview will be audio-recorded. To preserve anonymity the audio recording will be stored under a code and will not be associated with your name or e-mail address. The script will then be transcribed by a freelance external transcriber into an electronic document. Interview recordings and transcripts will be kept on a personal computer which is password protected and only accessible by the primary researcher. The audio files and transcripts may be made available to the whole research team to support data analysis. Individual interview findings may be aggregated anonymously, and research reported on aggregate results.

Participation in the interview is voluntary. Your decision to participate will not affect your relationship with the University or the research team. If you decide to take part, you will be requested to sign a consent. You are still free to withdraw from the study at any time and without giving a reason.

If you have a complaint about the way you have been approached or treated during this study, please contact me or M(Sc) Health Informatics course coordinator; Dr Lucy Hederman.

Publications: It is hoped that the results of this research may be submitted for publication in healthcare and health informatics journals. The results may be disseminated at relevant conferences.

## Informed consent form for participant

**Title of the project: “Towards creating a standard for the medication reconciliation capture in electronic medication management systems”**

Name of the principal researcher:

Clíodhna Cotter, School of Computer Science and Statistics, Trinity College Dublin.

Email: [ccotter@tcd.ie](mailto:ccotter@tcd.ie)

Background of the research: The objectives of this qualitative research are to explore the relevance and functionality required for electronic medication reconciliation capture. Your participation will help inform the development of a prototype for electronic medication reconciliation which could be considered for current and future electronic medication management systems. This research is being conducted as part of an M(Sc) in Health Informatics through Trinity College Dublin.

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Participation in the interview is voluntary. Your decision to participate will not affect your relationship with the University or the research team. If you decide to take part, you will be requested to sign a consent. You are still free to withdraw from the study at any time and without giving a reason.

If you have a complaint about the way you have been approached or treated during this study, please contact me or the course co-ordinator of the M(Sc) Health Informatics course; Dr Lucy Hederman.

Publications: It is hoped that the results of this research may be submitted for publication in healthcare and health informatics journals. The results may be disseminated at relevant conferences.

**DECLARATION:**

- I am 18 years or older and am competent to provide consent.
- I have read, or had read to me, a document providing information about this research and this consent form. I have had the opportunity to ask questions and all my questions have been answered to my satisfaction and understand the description of the research that is being provided to me.
- I agree that my data is used for scientific purposes and I have no objection that my data is published in scientific publications in a way that does not reveal my identity.
- I understand that if I make illicit activities known, these will be reported to appropriate authorities.
- I understand that I may stop electronic recordings at any time, and that I may at any time, even after my participation, have such recordings destroyed (except in situations such as above).
- I understand that, subject to the constraints above, no recordings will be replayed in any public forum or made available to any audience other than the current researchers/research team.
- I freely and voluntarily agree to be part of this research study, though without prejudice to my legal and ethical rights.
- I understand that any answer I provide is in a personal capacity and my own opinion and is not in connection with the organization for which I work.
- I understand that I may refuse to answer any question and that I may withdraw at any time without penalty.
- I understand that my participation is fully anonymous and that no personal details about me will be recorded.
- I have received a copy of this agreement.

\_\_\_\_\_  
Name of participant                      Date                      Signature

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

\_\_\_\_\_  
Researcher                      Date                      Signature

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## Towards creating a prototype for the medication reconciliation capture in electronic medication management systems

Status
View
Assign Supervisor

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Submitted by [ccotter](#) on Tue, 02/06/2018 - 22:26

• [Project overview](#)

**Name of Applicant:**  
Clíodhna Cotter

**Academic Supervisor / Lead Researcher:**  
Ms Gaye Stephens

**Research Project Type:**  
Element of Taught Postgraduate Course

**Project Duration:**  
Tuesday, February 6, 2018 to Friday, August 31, 2018

• [Funder](#)

**Funder:**  
N/A

• [File Attachment](#)

**REC Application Form:**

Filename	Date Uploaded	Size
<a href="#">REC Form.pdf</a>	2018-02-28 17:00:54	527.52 KB
<a href="#">REC Form PDF 2.pdf</a>	2018-04-19 17:25:48	533.95 KB

• [Admin fields](#)

**Academic Supervisor / Lead Researcher (username):**  
gstephen

**Application Number:**  
20180204

**Final Comments:**

The comments have been addressed and the application can now be approved.

**Status:**  
Approved