CORA Cork Open Research Archive
Cartlann Taighde Oscailte Chorcaí

Title	Data quality in the evolving digitised health service
Authors	McKernan, Joye
Publication date	2021
Original Citation	McKernan, J. 2021. Data quality in the evolving digitised health service. PhD Thesis, University College Cork.
Type of publication	Doctoral thesis
Rights	© 2021, Joye McKernan. - https://creativecommons.org/licenses/by-nc-nd/4.0/
Download date	2026-11-06 12:13:36
Item downloaded from	https://hdl.handle.net/10468/13595

UCC
University College Cork, Ireland
Coláiste na hOllscoile Corcaigh

Ollscoil na hÉireann, Corcaigh

National University of Ireland, Cork



Data quality in the evolving digitised health service

Thesis presented by

Joye McKernan

BSocSc, MPH, HDip in Computer Studies

for the degree of

Doctor of Philosophy in Medicine and Health

Research conducted at the National Perinatal Epidemiology Centre,

the Department of Obstetrics and Gynaecology,

and Cork University Maternity Hospital, Cork.

University College Cork

School of Medicine, Department of Obstetrics and Gynaecology

Head of Department: Professor John R. Higgins

Supervisors: Professor Richard A. Greene and Dr Paul Corcoran

2021

Table of Contents

Table of Contents ..... **ii**

List of Tables ..... **vi**

List of Figures ..... **vii**

List of abbreviations ..... **vii**

Declaration ..... **ix**

Acknowledgements ..... **x**

Abstract ..... **xii**

Chapter 1: Introduction **16**

1.1 Introduction 16

1.2 Definitions 19

1.3 Electronic Health Records (EHRs) 19

1.3.1 Implementing an EHR 21

1.3.2 Staff Members 22

1.3.3 Patients 23

1.4 Data Quality 24

1.5 Data Quality Framework 26

1.6 Measuring quality of digitised maternity care data 27

1.7 Local research environment 28

1.8 Methods 29

1.9 Summary 30

1.10 Thesis outline 30

1.11 Objectives of each chapter 33

Chapter 2: Electronic Health/Medical Records in Obstetric and Perinatal Care **36**

2.1 Abstract 36

2.2 Introduction 37

2.3 Terminology 38

2.4 The evolution of the electronic health record (EHR) 38

2.5 A global perspective of the EHR in 2018 39

2.6 Advantages and disadvantages of the EHR 40

2.7 eHealth Strategies 40

2.8 EHRs in Ireland 42

2.9 Conclusion 51

Chapter 3: Patient experience of the Electronic Health Record in a maternity unit in Ireland 55

3.1 Abstract 55

3.2 Introduction 56

3.3 Methods 58

3.4 Results 59

3.5 Discussion 63

3.6 Strengths and Limitations 65

3.7 Conclusion 65

Chapter 4: Examining the implications of the implementation of an Electronic Health Record on staff: lessons learned 67

4.1 Abstract 67

4.2 Introduction 69

4.3 Methods 70

4.3.1 Pre-implementation survey 70

4.3.2 Post-implementation survey 70

4.3.3 Post-implementation documentation audit 72

4.4 Results 73

4.4.1 Pre-implementation survey 73

4.4.2 Post-implementation survey 74

4.4.3 Post-implementation documentation audit 79

4.5 Discussion 79

4.6 Conclusion 82

Chapter 5: Applying a National Data Quality Framework on a clinical audit: the national audit of Obstetric Haemorrhage in the Republic of Ireland 2011-2013 84

5.1 Abstract 84

5.2 Introduction 86

5.3 Objectives 87

5.4 Methods 87

5.5 Results 90

5.6 Discussion 94

5.6.1 Comparison with other studies 94

5.6.2 Strengths and limitations 95

5.6.3 Implications 95

5.7 Conclusion 96
Chapter 6: Investigating Data Quality in an Electronic Health Record 98
6.1 Abstract 98
6.2 Introduction 100
6.3 Methods 102
6.4 Results 107
6.5 Discussion 113
6.6 Conclusion 117
Chapter 7: An exploration of handover practices following the introduction of an Electronic Health Record 119
7.1 Abstract 119
7.2 Introduction 121
7.3 Methods 122
7.4 Results: 125
7.4.1Observation study results: 125
7.4.2 Results of staff survey: 126
7.4.3 Key areas to be addressed 130
7.5 Discussion 130
7.6 Conclusion 133
Chapter 8: Discussion 136
8.1 Introduction 136
8.2 The key considerations in developing an EHR 140
8.2.1 Main findings 140
8.2.2 Implications for clinical practice 141
8.2.3 Healthcare policy 142
8.2.4 Recommendations for future research 143
8.3 Patients views and requirements around digital healthcare 143
8.3.1 Main findings 143
8.3.2 Implications for Clinical practice 144
8.3.3 Healthcare policy 144
8.3.4 Recommendations for future research 144
8.4 Staff Perceptions following the implementation of the EHR 145
8.4.1 Main findings 145
8.4.2 Implications for Clinical practice 146

8.4.3 Healthcare policy 146
8.4.4 Recommendations for future research 147
8.5 Standardized Frameworks 147
8.5.1 Main findings 147
8.5.2 Implications for Clinical practice 148
8.5.3 Healthcare policy 148
8.5.4 Recommendations for future research 148
8.6 Data Quality Assessment and Improvement 149
8.6.1 Main findings 149
8.6.2 Implications for Clinical practice 149
8.6.3 Healthcare policy 149
8.6.4 Recommendations for future research 150
8.7 Service culture and its effects on aligned data use 151
8.7.1 Main findings 151
8.7.2 Implications for Clinical practice 151
8.7.3 Healthcare policy 151
8.7.4 Recommendations for future research 152
8.8 Strengths and limitations 152
8.9 Conclusion 152
References 155
Supporting materials 169
Appendix I: Glossary Terms from Chapter 170
Appendix II: Supplementary table from Chapter 3 172
Appendix III: Patient Survey from Chapter 3 173
Appendix IV: Staff Questionnaire from Chapter 4 176
Appendix V: Supplementary figure from Chapter 4 182
Appendix VI: Supplementary file from Chapter 5 183
Appendix VII: Search strategy for MOH Data quality from Chapter 5 185
Appendix VIII: Supplementary file from Chapter 6 186
Appendix IX: Supplementary information from chapter 6 188
Appendix X: Clinical Handover and the Electronic Health Record staff survey from chapter 7 191
Appendix XI: Researcher's Personal Account 195

List of Tables

Table 1.1: Objectives of each chapter..... 33
Table 2.1: Suggested key points for the planning phase of an EHR..... 45
Table 2.2: Suggested key points for the implementation phase of an EHR..... 49
Table 2.3: Suggested key points for the optimisation phase of an EHR 51
Table 4.1: Themes and Quotes 77
Table 6.1: The reports reviewed, and the variables examined..... 105

List of Figures

Figure 2.1: MN- CMS Governance model for the development of the EHR 44
Figure 3.1:The Consultation and Relational Empathy (CARE) Measure 60
Figure 3.2: Patient views on the implementation of the new system 62
Figure 4.1: Timelines of methodology 73
Figure 4.2: Perceptions about the EHR introduction from motivated staff 74
Figure 4.3: Participants perception of the EHR 75
Figure 4.4: Staff Primary Concerns 76
Figure 4.5: Behaviour and attitudes regarding documentation 77
Figure 4.6: Audit results for booking visits report 79
Figure 5.1: The suggested audit process incorporating data quality assessment 91
Figure 5.2: Data completeness of all the sections in the MOH dataset 92
Figure5.3: Data completeness for the section “clinical records and documentation” in the MOH dataset 93
Figure 5.4: Data quality of the five dimensions for the Major Obstetric Haemorrhage (MOH) dataset 93
Figure 6.1: The dimensions of Data Quality as defined by Health Information and Quality Authority 104
Figure 6.2: MN-CMS data as per the HIQA data quality framework 108
Figure 6.3: Percentage of missing data in 2018 for the reports; daily delivery, breastfeeding, neonatal discharge and pregnancy loss. 109
Figure 6.4: Percentage of missing data in 2019 for the reports; daily delivery, breastfeeding report, neonatal discharge, and pregnancy loss. 110
Figure 6.5: Percentage of corrections carried out by the Data Quality Manager on the daily delivery report 111
Figure 6.6: Percentage of missing data in 2020 for the reports; daily delivery list, breastfeeding report, neonatal discharge, and pregnancy loss. 112
Figure 6.7: Percentage of missing data 2018 to 2020 for reports daily delivery report, breastfeeding report, neonatal discharge, and pregnancy loss report. 113
Figure 7.1: Outline of steps taken 124
Figure 7.2: Cause and Effect Diagram 129
Figure 7.3: Project Plan Outline 134

List of abbreviations

AE	Adverse event
AI	Artificial Intelligence
CARE	Consultation and Relational Empathy
CRF	Case Report Forms
CPR	Computerized Patient Record
CUMH	Cork University Maternity Hospital
DQM	Data quality manager
EHDS	European Health Data Space
ECR	Electronic Clinical Records
EHR(s)	Electronic Health Record(s)
EMR	Electronic Medical Record
EPR	Electronic Patient Record
ESRI	Economic and Social Research Institute
EU	European Union
FPM	Family Practice Management
GDPR	General Data Protection Regulation
KDP	Key Data Points
LIGG	Local Information Governance Group
HCP	Healthcare professional
HIQA	Health Information and Quality Authority
HIS	Health information Systems
IHI	Individual Health Identifiers
IS	Information Systems
ISBAR	Introduction, Situation, Background, Assessment and Recommendation
IT	Information Technology
IoT	Internet Of Things
MN-CMS	Maternal & Newborn Clinical Management System
MOH	Major obstetric Haemorrhage
MRNs	Medical Record Number
NICU	Neonatal Intensive Care Unit
NPEC	National Perinatal Epidemiology Centre
PAEHRs	Patient accessible Electronic Health Record(s)
ROI	Republic of Ireland
SBAR	Situation, Background, Assessment and Recommendation
SMM	Severe Maternal Morbidity
UCC	University College Cork
US	United States

Declaration

This is to certify that the work I am submitting is my own and has not been submitted for another degree, either at University College Cork or elsewhere. All external references and sources are clearly acknowledged and identified within the contents. I have read and understood the regulations of University College Cork concerning plagiarism and intellectual property.

Acknowledgements

Firstly, I wish to acknowledge my supervisors Professor Richard Greene and Dr Paul Corcoran. Thank you for this opportunity to complete this project.

Paul, I can't thank you enough for your patience and kindness throughout this research. Thank you for listening to the ideas and working them out with me. Thank you for taking the time to explain things in your clear, concise manner. I can only hope to have your level of calmness and clarity of thought throughout my career.

Richard, thank you for this opportunity, I know I am very lucky to have worked on this project with you. You truly are an inspirational leader and manager. I can't thank you enough for spending time discussing data with me. What I have learned from you goes far beyond these pages. You have guided, listened, and helped me when I needed it and you have given me confidence in my abilities, for this I will be eternally grateful. You are a treasure of a person. Thank you for helping me reach for the stars!

To all my colleagues in NPEC especially Indra, Irene, Sara and Edel thank you for being supportive and willing to discuss a project. I always appreciated the listening ear when needed. I am very proud to be part of the NPEC team and value all the work we do together. I am always grateful for the cakes, coffee, and chats we have.

To my colleagues on the 5th floor thank you for discussions and interest in the PhD. It was lovely to have colleagues to bounce ideas off and have a giggle with. Thank you, Claire O'Halloran, Nilima Pandit and Orla Sheehan for the in-depth discussions and questions about EHRs, data and data quality in the maternity services.

To all my buddies, thanks for listening to the random chats about EHRs, data and data quality. Thank you to Meg, Sarah, Laura Finn, and Laura for always being there with words of encouragement. Thank you, Kathryn Neville, for

being a mentor, colleague, and friend. Thank you for telling me to keep going and always checking in making sure I was getting there.

Thank you to my family for always supporting me and for just being the best, I am grateful to have the words of encouragement from my sisters Lucy and Amy and the hugs and support from my nieces Louise and Casey and my nephew Calvin.

To my parents thank you for everything, to my dad thank you for the walks, coffee and talking things through with me.

Mum, thank you for just being the most amazing human ever. You have listened, discussed, supported, and given me the strength to finish this work. Love you always Mum!

I am grateful to all those who participated in this research, I am thankful for the time and energy you gave these projects. I am always grateful for people that complete questionnaires and those who participate in research.

Abstract

Background/Objective

The research undertaken for this thesis focussed on data quality in the evolving digitised health service. In Ireland we all need to have our details on an electronic healthcare record. We need to have fully integrated systems documenting our health information across our whole life. We as patients need to be central to our care and have access to our data. EHRs can change healthcare by saving money, improving communication, and reducing errors. The introduction of an EHR is a substantial change management project that needs to include all stakeholders to ensure success. It requires vision, dedication, time, and patience. The power and importance of data cannot be overemphasised; we need to analyse what is required from data, using robust standard approaches, and ensure data is of high quality so that it can be used to improve patient outcomes and improve staff working conditions. The aim of this research project was to focus on aspects of digitisation that go towards achieving a high-quality data repository. We aimed to investigate the development and use of an EHR in the Irish healthcare system with specific consideration to the elements that impact data quality. We examined the experiences of the development team, patients, staff, service culture and the data collected.

Methods

We used both quantitative and qualitative methods; this mixed method approach allowed for a deeper understanding of the issues. A document analysis of the closure report of the implementation of the EHR (MN-CMS) from the national project team was supported with discussions with team members. Patients at antenatal booking visits in an Irish maternity unit were invited to participate and complete a survey with respect to digitization of their health data. The survey was divided into three distinctive sections; participant information, regarding the staff encounters on their visits and questions about the new system.

To engage with staff a pre- EHR implementation survey, a post EHR implementation survey and a post-implementation EHR documentation audit was carried out.

A four-step approach was required when applying a national framework to a national data set. The four steps included a literature review, using elements of a data quality framework to develop the planning of an audit tool, data quality assessment of the Major Obstetric Haemorrhage (MOH) audit dataset. The fourth step assessed the data quality using the five dimensions of quality: (1) relevance, (2) accuracy and reliability, (3) timeliness and punctuality, (4) coherence and comparability, and (5) accessibility and clarity.

To explore data quality in an EHR two phases were used; initially we examined the data from year 1 (2018); following analysis of the data set we found data quality issues. We then enacted an intervention and assessed the effect of a new data quality process. The intervention was to introduce a data quality resource to assess the datapoints within 1-2 days after documentation of the care by the healthcare professional. We assessed clinical data extracted from the MN-CMS national database for missing data and then examined the significance of the data issues.

An ethnographic study approach was used to explore service culture around shift clinical handover, the process was divided into three components: an observational study, a short staff survey and a cause-and-effect assessment.

Results

This project showed that several factors, need to be explored to fully understand data quality in healthcare. There is a growing need for high quality clinical 'Big Data' to measure, enhance and evaluate healthcare; clinical data systems need to be producing high quality complete and accurate data for primary and secondary use. Patients want to have access to their records and want to engage with healthcare professionals in their care. This engagement will lead to patients having more control over their health outcomes. EHRs are now becoming more and more widespread globally; in Ireland the Maternal & Newborn Clinical Management

System (MN-CMS) has been implemented for four maternity units and is a pathfinder EHR project. It is a clinically led, patient centred EHR. Staff engagement is required for the implementation phase; they are a vital component to ensure a successful implementation. Staff may require additional training to ensure their documentation positively impacts data quality. There is a requirement to standardise terminology in relation to data quality and use data quality frameworks to assess the dimension of data quality. It is meaningful and useful to apply national data quality frameworks to data sets to investigate where improvements may be made. Capturing and ensuring quality data from an EHR takes time and resources; the data needs to be examined for accuracy and completeness. Resources in the form of staff are required to achieve this impact on data quality. They can improve data directly and more importantly they can engage with staff regarding their documentation, identify need for further training, technical solution changes and indeed review of data points and the value of recording them. Following the implementation of an EHR, workflows and practices might not change when they should have; it is important to explore why these changes may not occur and address the issues to identify the barriers and allow enablers to achieve appropriate change, engaging with staff in the process.

Conclusion

This project aimed to explore the impacts of digitizing healthcare documentation on the quality of that data, examining the impact through patients, staff, and processes. This thesis has shown a need to move towards standardised terminology and methodologies to achieve these goals and the projects involved took a practical solutions approach. We have shown the importance of staff members and their role in the success of the project implementation. We have highlighted the importance of the use of frameworks to robustly assess data quality. There is growing literature regarding EHRs and data quality with the rapid expansion in digitization of healthcare data. This thesis adds to that literature, but significantly more work is needed in the areas of standardisation of data quality frameworks, the importance of staff in data quality, and co-designed patient portals.

Chapter 1 - Introduction

Chapter 1: Introduction

1.1 Introduction

Data is becoming ever more central to our lives; it is used in monitoring our daily activities at work and in leisure. It is central to corporate and state policy development and government decisions. The digitization of health data has been slower to develop and consolidate; its place within the healthcare setting is now evolving at pace. While not always easily available, the value of good quality data to manage healthcare and improve outcomes for patients has long been known and understood. Florence Nightingale, the great nurse/healthcare administrator and passionate statistician, who showed the qualities required to reflect and analyse social data in the mid-1800s, noted [1,2] *"I had begun to see that good quality data, properly interpreted, can be a power for good in all areas of medicine and health. I collected as much evidence on hospitals and public health as I could to form the basis of my knowledge"* [2]

The necessity to have quality health data has never been more evident as we live through the COVID-19 pandemic. High quality, timely data ensures that policymakers and epidemiologists are able to model and plan. Deficits in such data leaves healthcare systems vulnerable, healthcare staff uncertain in their practice and can lead to uncertainty and lack of trust from patients and service users.[3] Many healthcare providers are now using health data to manage hospitals, drive change and predict healthcare outcomes, individualize care, make health safer and ensure value for money. Data should allow us to make better decisions and organize ourselves more efficiently. The efficient and effective documentation of care, allowing the collection of high quality data is key to ensuring its transformation into useful information and intelligence.[4–6]

The development of artificial intelligence (A.I.), genetics, use of algorithms and the threat of future pandemics signals the requirement for healthcare investment in high quality information systems. This requires clear planning and standardization of processes around data capture and analytics and the need for quality software and hardware functioning at a high level. [6] There is a requirement to develop data

science skills to allow healthcare systems enhance healthcare standards, value for money and the patient experience.[7]

Digitizing data management in healthcare may be technically achieved by different approaches – be that single vendor systems or multivendor 'best of breed' systems interfaced to a single data repository. Irrespective of the technical approach, a complete record of the patient's healthcare data that is accurate, complete, longitudinal, and available at all points of contact with the health service irrespective of geography, discipline or care service is the evolving requirement being fulfilled by the Electronic Health Record (EHR).

In the report *Developments in Healthcare Information Systems in Ireland and Internationally* 2021 published from the Economic and Social Research Institute (ESRI) they note that health information systems (HIS) and digital health solutions are strategic priorities for the healthcare sector in Ireland. They comment that even though many policy frameworks have outlined how to adopt tools like EHRs and individual health identifiers (IHIs) on a national scale they have yet to be realised.[8] This report provides an overview of what is happening in Ireland at present and how the healthcare sector could learn from others internationally in particular Scotland, Estonia and Denmark. The Irish Healthcare System learned a great deal during the COVID-19 pandemic and must be encouraged by how fast decisions were made. In this report one element that is highlighted is the two-tiered healthcare system that prevents a consolidated approach to patient care. Even though there are changes that could be made to achieve small wins the development of an adequate HIS in Ireland should be a long term goal.[8]

The Sláintecare Implementation Plan states that ICT (information and communications technology) "ICT has the potential to be the biggest and most effective driver of change and improvement for better patient outcomes across the health system. In the future, a coherent suite of eHealth solutions will underpin and support our overall vision for integrated, patient-centred care, population health planning and more effective and safe delivery of health services.

Patients and health professionals will have ready access to clinical records and administrative information, which will enable better decisions to be made."[9]

The European Commission has launched the *European Health Union: A European Health Data Space for people and science (EHDS). The EHDS "is a health-specific data sharing framework establishing clear rules, common standards and practices, infrastructures and a governance framework for the use of electronic health data by patients and for research, innovation, policy making, patient safety, statistics or regulatory purposes."*[10] The EHDS aims to allow individuals to fully exercise their rights over their data so that is can be shared, easily accessible and provide protection be in line with data regulations. This should allow for the shared health data across borders, for staff it means that health data will be improved by better interoperability. [10] As there is a move towards improving health data for individuals this will allow individuals to be shared decision makers in their health. The Irish healthcare system has a long road ahead but there are elements that have already been implemented that could encourage the development of a digital spine. MN-CMS is an example of an EHR that could provide valuable lessons to the system, how it was implemented, the primary and secondary data use, patient involvement and staff issues. EHRs have the potential to provide data that drives improvements and better outcomes for the healthcare system.

However, with the development of EHRs, one element that needs particular attention is data quality. Healthcare is a very complex data-rich environment and good quality primary data collection in the documentation of care offers enormous potential to:

- Ensure Quality of care and patient safety
- Allow assessment of the care provided
- Provide reassurance for patients and healthcare managers
- Relate care to cost and value
- Assess complex ecosystems and treatments
- Provide a valuable dataset for clinical and translational research

A data-driven healthcare system opens several possibilities that will improve outcomes for the patient and save money for healthcare providers.[7] At TechCrunch Disrupt SF, 2013 Vinod Khosla noted that "In the next 10 years, data science will do more for medicine than all the biological sciences combined"; Khosla reiterated his prediction in 2019 acknowledging that traditional healthcare will also continue to improve.[11] For this prediction to come to fruition it requires access to good quality healthcare data. There have been a number of advancements in technology and evidence from practice in countries that are further along the road of digitizing healthcare information suggests such 'success' will be limited, unless we ensure 'data' interoperability and data quality.[12,13] I will discuss data quality and examine the impact of good data on healthcare systems. This chapter will conclude with a brief outline of each of the studies. Finally, I will present the aims and objectives of the thesis.

1.2 Definitions

For this thesis, the term Electronic Health Record(s) (EHR(s)) is used throughout and is defined as "a repository of information regarding the health status of a subject of care, in computer processable form" from the International Organization for Standardization.[14–16] The terminology used for the EHR (in the international literature is very mixed and even confusing and there is a need to consolidate the terminology for future research questions. However, there are currently many variations in the definition of the EHR in health information systems: these include Electronic Medical Record (EMR), Electronic Patient Record (EPR), and Computerized Patient Record (CPR), etc.[15,17] and the terminology is often used interchangeably. EHRs collect, store, and allow access to information for a longitudinal health record, available to several parties across a multidisciplinary team including the patient/service user. [16,18]

1.3 Electronic Health Records (EHRs)

Worldwide an increasing number of countries are moving to EHRs[19] with the promise of providing enhanced patient care, improved system integration,

availability of patient data for multidisciplinary teams, and improved measurement of care and better outcomes; this will lead to improved care for patients. EHRs have an impact on safety and quality of care.[20,21] There is also a move towards data availability for research purposes, including clinical trials and the accessibility to such trials for patients using the information provision within EHRs.

EHRs need to be patient-centred to include the patient in their own care by having the capacity for patient involvement through portals or at-home devices (self-monitoring) that can feed into the record.[15,22–24] The development of the Internet Of Things (IoT) and its implementation into healthcare systems will improve predictive care and diagnostic accuracy for patients.[25] Substantial capital is now being invested in EHRs; there are high expectations for what the EHR can deliver as they become the information backbone of healthcare systems.[22,24] Greenhalgh et al. (2009) stated that EHRs are set to modernise healthcare by making care better, safer, and cheaper. They suggested that duplication, drug administration errors, and mistaken identity would no longer cause problems for patients, hospitals, or staff members.[26] EHRs allow for improved communication across medical teams(all staff grades and across all disciplines), allowing for legible and complete documentation.[26,27] In essence, EHRs support data collection, storage, and access to patient health information; they can be used at the patient bedside, at the central working station, or on a personal device.[18,23,28]

With these new data collection opportunities, EHRs can change research practice and answer questions using 'Big' real world data; not always easily answered using traditional research practices, e.g., randomized clinical trials. Advances in data science around social media has offered significant insight to the commercial and marketing industries, the availability of similar large datasets in EHRs, will revolutionise healthcare and healthcare research.[7] These records can be used to assess the effect of public health campaigns, the uptake of best evidence in care and assist in developing quality and outcome registries.[23,29,30]

The implementation of EHRs is not without problems, they are not just technical changes, they involve a change project with significant transformation and involve areas including people, processes and technology. There can be significant issues relating to "off the shelf" systems compared to clinician-built systems.[26] There are increased costs with adoption and implementation as hardware and software upgrades will be needed. Training staff as end users and the continued staff training increases costs. Issues can arise regarding data security and data protection.[24,30,31] Quality and safety measures need to continue at a high standard and lessons need to be learnt from other healthcare settings regarding issue that have arisen for them in particular in relation to prescribing issues.[32] The return on investment is not immediate and is probably not available for about 10 years but quality and safety measures begin to appear in the early years.[21]

1.3.1 Implementing an EHR

Implementing an EHR is a significant change program for any organization.[33] However, an EHR can impact healthcare and offer solutions that traditional paper-based charts do not. If the implementation is carried out correctly, the quality of care will improve; however, if the implementation process is suboptimal, there may be risks to patients and unrealistic expectations.[34–36] The implementation of an EHR should lead to an improvement in quality management, and this is key to why policy makers are driving for this change as it impacts patient safety, staff members, cost, and improved management structures.[37]

Implementing an EHR takes time, dedication, and focussed plans of defined workflows. Good working relationships are required with the vendor, early staff engagement is required, and continuous evaluation is needed. The right people need to be involved from the beginning and be willing to adapt and evolve as the project progresses. EHRs allow for an assessment and update of workflows which following review may introduce new issues. Dedicated and resourceful personnel are a vital part of the success of the implementation.[38] The implementation of an EHR is multi-layered, and the barriers or facilitators that affect success are found

in the literature.[17,39,40] Baseline data prior to the change to an EHR may assist[36,41,42] documentation of the benefits achieved. A process of continuous evaluation is a key to learning the successful elements and improving the deficits.

The first national project undertaken in the Republic of Ireland to implement an EHR is the Maternal & Newborn Clinical Management System (MN-CMS). MN-CMS is the design and implementation of an EHR for women and babies in maternity services in Ireland.[43] It is a phased project that is clinician-led and patient-centred. The involvement of clinicians in the implementation impacts the project's success and ensures responses to issues as they emerge.[44] The implementation of the MN-CMS project will be discussed in greater detail in chapter two.

1.3.2 Staff Members

The vital component of an EHR implementation is the 'people' – the multidisciplinary healthcare staff. Staff members' adaption to the EHR impacts on a successful implementation and transition to an optimisation phase.

Clinicians are busy people who need to feel comfortable and confident in the systems they are using. Their goal is to provide efficient, safe, and effective care for the patient in front of them. EHRs are created to make their lives easier; however, this may not be the initial perception of staff: changes to workflows and electronic documentation can be daunting, and change can be slow. Moving from text documentation to more structured documentation such as a simple tick, selecting from a drop-down, and searching for correct codes can enhance the collected data but involves change. Staff may feel that data entry takes too much time in the early phase after go-live. They may cut corners or find workarounds in the system, which can lead to work inefficiencies; it also leads to poor quality or missing data, adding time and effort as the data needs to be fixed by other staff, and it means the potential for patient information being incomplete the next time they present at the healthcare facility.[45]

Clinicians need to improve documentation and may need encouragement to achieve these goals. There is a requirement for education in standardising documentation and how good documentation can lead to understanding care more effectively and providing it more efficiently.[46] One key element of implementing the EHR is the potential time saving for staff. However, additional time is needed for training in the initial stages, which can prevent successful implementation. Staff members need to be first trained on using the EHR and understanding the new workflows. They will need continuous refresher sessions after the initial implementation to embed good practice. Studies have shown that staff efficiency may decrease as they familiarize themselves with the system; however, staff productivity returns to a high level in time.[28] Ni, K *et al.* (2019) found in their study that staff workload impacted the quality of documentation and commented about data suitability for secondary use.[45] Koh and Ahmed (2021) commented that educational work may be useful, however they were able to make changes to improve clinical documentation by redefining the end-user needs following feedback from their study.[47]

The initial implementation phase needs to be resourced to capture these issues so a system of verification checks may be applied to the data workflow to allow issues to be captured. There are increased risks following the immediate implementation of the EHR; however, contingency plans can be put in place early in the process to mitigate these.[36,48]

An improvement in documentation leads to complete documents for clinical care, clinical outcomes, business reporting, litigation and risk assessments, and secondary use.[20,30,45] However, the transition from paper to EHR can be time-consuming and delay staff in completing documentation adequately. A focus on documentation highlights the need to address any data quality issues that may arise.

1.3.3 Patients

Patient data is the foundation of the EHRs, their data deserves to be treated with respect, and every effort must be made to ensure the accuracy of the data, including patient review and input. The benefits of EHRs are evident for patients;

there is improved documentation, improved patient safety, and staff members may have more time with patients. EHRs offer the potential to reduce risk but do need to be monitored continuously to achieve this outcome.[49]

EHRs can have patient portals that will allow patients to access their data.[50] Improved communication between the healthcare professional (HCP) and the patient will improve adherence to treatment plans and clinical outcomes.[51]

1.4 Data Quality

Data quality is defined by Health Information and Quality Authority HIQA in Ireland as "Data that are complete, valid, accurate, reliable, relevant, legible and available in a timely manner."[52] In the healthcare setting, data is becoming more and more important for clinical decisions and secondary use of this data offers great opportunity for service improvements.[53] We need quality data for better decision-making, healthcare management, policy development, public health campaigns, and population health evaluation. Public health shows how well a society is, and data is needed to drive change and influence better outcomes. Health data can be used to drive change for patients, staff, clinical services, hospitals, and healthcare services; it can assist in the reorganisation of systems that may no longer be functioning well. EHRs are the primary source of this data; the higher the quality, the better the inference and outcome.[54–56] EHR data quality affects the validity and reproducibility of research results.[57]

EHRs have thousands of data points, which may have errors that can lead to issues and concerns for patient safety.[58,59] Fowles *et al.* note that studies have shown variation in missing data across different locations; variation can occur even within the same organisation.[60] There is limited literature examining and measuring data quality at an individual healthcare facility.[61] Poor data quality may not immediately affect healthcare facilities; however, the effects may cause issues for patient safety and the implementation of quality improvement measures over time.[37] Studies have found inconsistency in coding systems such as SNOMED, ICD10, etc.; this may be that staff are not trained to code cases, leading to inaccuracies.[23,55] EHRs may not have the tools built-in yet to improve the completeness and

accuracy of data; however, there may be straightforward, practical measures that could be taken to validate the quality of data for example using a standard data set template for clinical handover, the use of strict data entry controls and the availability of training.[62,63]

EHRs can be used for secondary data use; researchers can easily see the value of sizeable individual-level data sets usable across several research methodologies. The potential of high-quality data in EHRs data repositories is huge; now may be the opportune time to move towards creating standard data quality practices. Even though the development and implementation of EHRs are increasing yearly, there has not been the development of data quality standards, and the language used to describe data quality is also inconsistent. Standard definitions will assist in validating and verifying data sets.[54,57,64]

The collection and use of data for healthcare are the key elements of the EHR. This 'simple' idea is complex and needs to be supported and prioritised to ensure the potential of the EHR is realised. The data needs to be verified and validated. Good data is necessary for effective interventions, better policy decisions, and improved work conditions. The EHR needs to be intuitive but strict controls for data entry need to be included. EHRs need to have structured data entry, including drop-down menus, pick lists, coding libraries within the workflow, etc., and limit the number of free text fields for data collection. HCPs need to receive formal training in the importance of data; including data quality, data structures, and, subsequently, training in health informatics.[24,30,57,60,62,65] The important step for HCPs is that they see the EHR as a tool that can assist in the development of an efficient, caring health system.[46]

The staff, patients, and management need to have confidence in the data from the EHRs and feel that it is of high quality and can be used to improve healthcare outcomes. Staff members need to recognise the importance of data for patient care. As countries and vendors are at different stages of implementation, the success of data extraction programs has been limited.[54] In their study, Scheid et al. (2019) noted that the data extraction program they used did not recognise the duplicated results initially. They suggested that results generated by electronic

extraction should describe and outline the collection, validation, and analysis involved.[59]

Any definition of data quality needs to consider data accuracy, data completeness, and timeliness. Data quality assessment audits, and data quality workflows need to be integrated into the workplace so that the data quality assessment and improvement are functional components of primary data collection. There is literature on the theoretical aspects of data quality, little on how this can be achieved in practice. One method of examining the data is to examine the function of each area and identify the data documented. This step-by-step approach may be completed during the development of workflows.[54,56,62] EHR vendors provide report functions with their software system; this is usually an agreed set of reports available for use and analysis. This reporting function of the healthcare entity needs to be resourced to maximise data quality, by identifying the problems, correcting them and preventing errors, with the expressed wish to enhance the value stream of good data.[66]

1.5 Data Quality Framework

There has been a move in the scientific literature towards the development of data quality frameworks. A data quality framework allows a systematic approach to documenting, assessing and improving data.[54,56] However, as noted earlier in this chapter, there is an issue with definitions and what steps to use. There have been data quality frameworks proposed that each discuss step-by-step approaches to reviewing the data to see if it is fit for purpose. Health Informatics researchers are even reviewing frameworks outside of health, such as business and the wider information technology area, to address the arising issues.[53,55,57] Researchers need to be consistent in their language and approach to data quality dimensions, and systematic approaches need to be developed and enhanced.[67]

For this thesis, we examined the use of a data quality framework proposed by the Health Information and Quality Authority (HIQA) in Ireland. HIQA is the independent authority established to drive high-quality and safe care for people

using health and social care services. HIQA has noted an urgent need to improve the structures to ensure data is not lost.[68]

1.6 Measuring quality of digitised maternity care data

This thesis is focused on the data and processes in maternity care. Maternity care documentation provides a rich source and vast amount of data. The maternity services are the first to move to an EHR (MN-CMS) in Ireland; on average, there are 60,000 deliveries in Ireland every year now, 40% of all births have their care documented on an EHR. MN-CMS was launched in Ireland in 2016, so the digital data available increases every year.[43] The maternity services have a long audit and outcome reporting tradition, for example reported data from the Rotunda hospital dates back to 1745.[69] Data are presented in annual reports from most hospitals, and these reports are available on the hospital's websites. The National Perinatal Epidemiology Centre (NPEC) was established in 2007 with a national focus in collaboration with all 19 of Ireland's maternity units. The mission of the NPEC is to collaborate with Irish maternity services to translate clinical audit data and epidemiological evidence into improved maternity care for families in Ireland. The NPEC has a national focus, working in collaboration with all 19 units: it audits and reviews the practice of the Irish maternity services to derive learning and make recommendations based on that learning. The NPEC collects annual data on Perinatal Mortality, Severe Maternal Morbidity, Very Low Birth Weight Audit, Home Births, Robson Ten Group Classification System, Neonatal Therapeutic Hypothermia, Maternal Death Enquiry, Republic of Ireland COVID-19 Study. https://www.ucc.ie/en/npec/

In Ireland, women choose a care pathway; they can have consultant-led care, midwifery-led care, early transfer home care or homebirth-supported care. The data examined for this thesis is that available for hospital-based care. The data can be analysed from the beginning of the pregnancy to discharge from the unit. There is also the opportunity to analyse data on the baby. The data can be analysed from a process and outcome perspective. A woman will have many visits/encounters throughout pregnancy, and a vast amount of data is created,

stored, and communicated. MN-CMS is in phase one and is rolled out to four of the nineteen maternity units in Ireland. As with other disciplines, there is an issue with agreed data definitions; however, MN-CMS is a step forward in the foundation of agreed data points in maternity care; it will become the single source of truth for maternity care in Ireland. The clinician-led project team is taking steps with suitable information governance structures to assist the foundations of data quality. The team collaborates with researchers for secondary data use and assists researchers with high-quality data.[43]

1.7 Local research environment

The maternity directorate of the Ireland South Women & Infants is linked with the academic partner of the Department of Obstetrics and Gynaecology in University College Cork (UCC). This directorate is Cork University Maternity Hospital (CUMH) as the tertiary centre, with the maternity units of South Tipperary General Hospital, University Hospital Kerry, and University Hospital Waterford. As part of the governance structures of the directorate there is a local information governance group (LIGG); the LIGG reports directly to the management of the Clinical Directorate.[70] The LIGG is a multidisciplinary group comprising of members from the four units.

The functions of LIGG in respect to data are:[1]

1. Examine the data reporting mechanisms within the Maternity Directorate
2. Assess the governance and management of data within the Maternity Directorate
3. Provide structure for data to be quality assured
4. Ensure data is quality assured for use in hospital reports, clinical guidelines, and research
5. Provide a framework for communication within the Maternity Directorate regarding the flow of data
6. Liaise with the Maternity Directorate Clinical Director regarding data collection

[1] The Local Information Governance Group (LIGG) Terms of Reference Document 2021

7. Provides in-depth reviews of the research and clinical audit applications for the Maternity Directorate EMC
8. Maintains the research/clinical audit database of all new and existing research/clinical audit activity throughout the Directorate

This governance group is a crucial component ensuring data is available for all purposes -research/audit/service evaluation within the clinical directorate. Two units within the directorate use the EHR, and over the last two years, there has been an increase in requests for maternity patient data. The LIGG has a rigorous process that includes validating and checking the data before it is released for any request.

- The clinical data is extracted from the MN-CMS national database. The MN-CMS system has a total of 30 national reports that are used in units for data validation and checking. The reports are used in the day-to-day management of the unit.
- The data quality manager (DQM) function arose from the findings of some of the work in this thesis. The DQM undertakes daily, weekly, and monthly data quality processes. These processes include checking for missing and inaccurate data. Daily data checks are carried out on missing data for all births and deliveries, weekly checks on neonatal outcomes, and monthly checks to ensure validation.
- The data is updated as best it can be however, it is impossible to update all data, and consequentially data may remain missing. The DQM interacts with the staff member requesting the completion of missing/inaccurate data assess the likely cause and training is provided to the staff member, if necessary.

As part of this thesis, the LIGG enabled the author to undertake a data quality audit and quality assessments to improve data capture.

1.8 Methods

The thesis led the author to explore data quality in the evolving digitised health service using the implementation of an EHR. This further allowed me to explore

the impact on patients, staff, and particularly data. As noted earlier in this chapter, the impact on data has a long-lasting impact on quality and safety for patients and the HCP. We believed that employing both quantitative and qualitative methods, were appropriate and would allow a deeper understanding of the issues raised. It is key for this project to generate learning points from the implementation, the use of the EHR and data quality that could impact the further roll-out of MN-CMS national project. The implementation of MN-CMS is a huge change management project and has encountered delays in being rolled out. For this thesis, it was important to adapt to these changes and not set out a strict evaluation piece as this would have limited the overall learning. As MN-CMS is the first EHR for the Irish Health System, it is important to use methods that staff members can replicate in other units. It is also important to allow a project to evolve and change to ensure that feedback can be used, and that research can be completed to improve the outcome continuously.

1.9 Summary

This thesis documents a series of studies that assess an EHR implementation effect on the quality of documented data including impacts on the service and other key considerations. There are many aspects to consider regarding the impact, as outlined above. Patients need to be kept at the centre of the development, and there needs to be excellent communication with staff members. The power and importance of data cannot be overemphasised; we need to analyse what is required from data, using robust data quality frameworks, and ensure data is of high quality that can be used to improve patient outcomes and improve staff working conditions.

1.10 Thesis outline

The research undertaken focusses on aspects of digitisation that go towards achieving a high-quality data repository. I undertook studies that aimed to investigate the development and use of an EHR in the Irish healthcare system with specific consideration to elements that are important for data quality. We examine the experiences of the EHR development team, patients, staff, staff culture, and

data. At the beginning of this research process MN-CMS was implemented in an Irish maternity unit. As this was the first EHR in Ireland it provided the author an opportunity to examine what influences data quality.

Each study has a place in the overall examination as it builds the elements that are necessary for good data quality. For the author an understanding of the implementation of MN-CMS was required; why move to an EHR? how does it provide data and what data can it provide? From examining the implementation of MN-CMS one key point that needed to be explored was how patients feel about data and move to MN-CMS. As I continued through the research process and to get a better understanding of the data it was necessary to survey the staff in the unit. An understanding of staff documentation practices was required to understand how the data was collected. Examining data quality is challenging and examining data using a data quality framework was necessary to understand the dimensions of data quality. It was necessary to undertake a data quality assessment of the data captured in the EHR and to see how an intervention could impact on the data quality. Finally following the data assessment piece, it was deemed necessary to explore how work culture impacted on data quality. Each stage of the research process led nicely from one area to the other and it showed how research evolves and that is necessary to be adaptable to what the research is showing.

The overall aims of the project are:

Aim 1: To investigate the considerations needed in developing an EHR

Aim 2: To explore patients views and requirements around digital healthcare

Aim 3: To examine staff perceptions following the implementation of the EHR in particular in relation to documentation.

Aim 4: To explore standardised frameworks

Aim 5: To undertake a data quality assessment and examine if improvements can be made.

Aim 6 To understand how work culture impacts data quality

It is envisioned that the findings of this thesis will inform practical solutions to the challenges of an EHR. This thesis helps show how data plays such an essential part in the EHR development for staff, patients, and future innovation and research.

In order to achieve these aims, this thesis is comprised of papers which are outlined below:

Chapter 1	Introduction and aims
Chapter 2	Electronic Health/Medical Records in Obstetric and Perinatal Care
Chapter 3	Original research; Patient experience of the Electronic Health Record (EHR) in a maternity unit in Ireland
Chapter 4	Original research; Examining the implications of the implementation of an Electronic Health Record on staff: lessons learned
Chapter 5	Original research; Applying a National Data Quality Framework on a clinical audit: the National audit of Obstetric Haemorrhage in the Republic of Ireland 2011-2013
Chapter 6	Original research; Investigating Data Quality in an Electronic Health Record
Chapter 7	Original research; An exploration of handover practices following the introduction of an Electronic Health Record (EHR)
Chapter 8	Discussion and conclusion

1.11 Objectives of each chapter

Table 1.1: Objectives of each chapter

Chapter	Title	Objectives
2	Electronic Health/Medical Records in Obstetric and Perinatal Care	This chapter presents the lessons learned and key recommendations from the closure report of the national project team of MN-CMS a complete EHR used for maternity services in Ireland. The objective of this chapter is to understand the development of the EHR.
3	Original research; Patient experience of the Electronic Health Record (EHR) in a maternity unit in Ireland	Following the introduction of the EHR (MN-CMS) for maternity services in Ireland the objective of this chapter is to explore the views of the patients using the service and examine what they want from an EHR.
4	Original research; Examining the implications of the implementation of an Electronic Health Record on staff: lessons learned	This chapter examines the staff perceptions after the implementation of the EHR. The main objective of this project was to examine how staff feel about the introduction and how the introduction has impacted on documentation.
5	Original research; Applying a national Data Quality Framework on a clinical audit: the National audit of Obstetric Haemorrhage in the Republic of Ireland 2011-2013	Internationally Major Obstetric Haemorrhage (MOH) is increasing and the need to capture useable, quality data to improve clinical practice outcomes is imperative. The objective of this study was to examine the data quality from a baseline national audit of MOH to inform the data specifications for a follow-up national MOH audit. By using the HIQA national guidance on a data quality framework for health and social care the aim of this study

		was to examine the completeness and accuracy of cleaned data.
6	Original research; Investigating data quality in an Electronic Health Record	The introduction of an EHR in the maternity healthcare system provided an opportunity to examine data quality. The main objective of the project was to examine the data collected and investigate how if the data could be improved by taking practical steps to improve the data.
7	Original research; An exploration of handover practices following the introduction of an Electronic Health Record (EHR)	Clinical handover may improve patient safety, remove the possibility of longer stays in hospitals, clinical errors, and duplication of orders. The objective of this study is to assess the use of the EHR in the process of shift clinical handover in a maternity unit.

Chapter 2: Electronic Health/Medical Records in Obstetric and Perinatal Care

McKernan J, Greene R, Robson M, O'Donoghue K.

Published in Book Series:
The Continuous Textbook of Women's Medicine Series
Volume: 3 – Elements of professional care and support before, during and after pregnancy
Link to chapter

Chapter 2:
Electronic Health/Medical Records in Obstetric and Perinatal Care

2.1 Abstract

Background/Objective Several countries have had varied success with implementation through to optimization stages. EHRs are being developed and introduced at an unprecedented rate in many countries. EHRs can change healthcare by saving money, improving communication, and reducing errors. This chapter presents the lessons learned and key recommendations from the closure report of the national project team of the Maternal & Newborn Clinical Management (MN-CMS) a complete EHR used for maternity services in Ireland.

Methods

A document analysis of the closure report from the national project team of the MN-CMS was completed. This report summarised key elements that can be used widely for the development of EHRs. Anecdotal findings were provided by the Obstetric Lead for the MN-CMS project.

Results

Key findings were outlined for the planning, implementation and optimisation stages of a national system using the MN-CMS as an example including the lessons learned and barriers experienced.

Conclusion

Globally the overall implementation of EHRs has not been as successful as it could have been and the benefits of EHRs have not been seen yet. However, digital technologies have transformed banking, finance, transportation, navigation, Internet search, retail, and now EHRs may bring the same revolutionary change to healthcare. This chapter highlights the development of an EHR as an example of a clinician led, patient focused, change management project.

Keywords:

Electronic health records, EHR development, EHR planning, EHR Implementation

2.2 Introduction

Every year more and more electronic health records (EHRs) are being introduced in Europe, North America, Australasia and the Middle East. The change from paper to electronic records has not always been a seamless or quick process, however EHRs are viewed as central to updating modern medicine especially regarding organisation structures and delivery of sustainable care.[19] Globally agencies are moving towards a more sustainable and holistic approach for the development and implementation of ehealth and mhealth healthcare strategies.[71] Campanella et al (2016) defines the Electronic Health Record (EHR) as "a systematic electronic collection of health information about patients such as medical history, medication orders, vital signs, laboratory results, radiology reports, and physician and nurse notes"[72] Menachemi and Collum comment that the Electronic health record (EHR) has the potential to alter healthcare systems from a mostly paper-based industry. They suggest that the EHR allows providers to deliver a higher quality of care.[31] The EHR is seen as a tool that will measure quality of healthcare and monitor ongoing provider performance. It will allow for the elimination of expensive and time consuming processes.[73] Boonstra et al note that the implementation of hospital wide EHR systems can be a complex matter. The authors carried out a systematic review on implementation of an EHR in hospitals. Twenty-one articles met their selection criteria. They commented that implementation needs a range of organizational and technical factors that include human skills, organizational structure, culture, technical infrastructure, financial resources, and coordination.[15]

An initiative, led by the Norwegian Institute of Public Health and the WHO Department of Reproductive Health and Research (RHR), with Queensland University, the University of Oxford, and the Health Information Systems Program Vietnam, is setting out a framework and tools for introduction of a system of eRegistries. The authors note that eRegistries have functionalities that provide the "potential to go far beyond simple registration tools, and constitute an entire ecosystem of public health information and communication strategies"[71]

The potential of registries may assist those who have not fully transitioned from paper based health information and they could provide an integrated electronic backbone.[71]

This chapter outlines the development of the EHRs, examining how they evolved, the global perspective, the users, and examines literature on the use of paper records versus electronic records. The chapter will then examine the planning, implementation, and the optimisation of an electronic health record (EHR) for all women and babies in maternity services; using as a model in the experience in Ireland: The Maternal & Newborn Clinical Management System (MN-CMS).

2.3 Terminology

For this chapter the terminology electronic health records (EHR) will be used. When reading information regarding electronic records two definitions are used frequently: -

(i) Electronic Medical Records (EMR)

(ii) Electronic Health Records (EHR)

The EMR examines a patient's medical history and is used by providers for diagnosis and treatments. The EHR is designed to be shared outside the individual practice and allows a patient's information to be updated from specialities to laboratories and imaging facilities, etc. The EHR provides information on the overall health of the patient.[74] The terminology used for electronic health records is a language in itself and some phrases are new to clinicians and patients. Appendix I contains a glossary of terms that are frequently used.

2.4 The evolution of the electronic health record (EHR)

For centuries, health records were written on paper, maintained in folders divided into sections, and only one copy was available. In the 1950's the computer began to replace traditional methods of accounting and book-keeping. The further development of computer software and hardware developments to allow computers to be progressed as data processors in the 1960's and 1970's laid the foundations for the development of the EHR. At this time academic medical centres initiated systems that compiled patient health information that could be

shared and managed at a central point.[75] Countries have taken different approaches to the deployment of the EHR; some have home grown systems in single organisations for example in the US; to interoperability standards for linking multiple information technology (IT) systems; to top-down, government driven, national implementations of standardised systems.[76] The United Kingdom, Australia and France have developed a national electronic medical record system.[77] A number of reasons have emerged suggesting why EHRs were not widely implemented across healthcare systems: these include high costs, data entry errors, poor initial physician acceptance and lack of real incentive. To develop and implement an EHR at the time would have been costly and the benefits may not have been widely shown. In the late 1980's and early 1990's, the IT world was changing, and software and hardware were becoming more affordable. The emergence of hand-held devices, mobile devices and the internet played a part in moving the EHR towards a cost-effective widely used record. [78] For some countries the move towards EHRs is only at the beginning, and while benefits are being noted for population health projects in countries with well-established projects there are still issues that have not been addressed. These include healthcare coverage, privacy, and especially the security of EHRs. There is an increasing demand from patients that they know their data is secure and safe.[50] Healthcare providers need to be able to provide assurance that measures are being put in place to ensure data security. The EHR produces vast quantities of data offering enormous opportunity for research towards improving care; however, the secondary use of data must be carried out ethically and with the knowledge of the patient.[78]

2.5 A global perspective of the EHR in 2018

EHRs are supplied by several international companies and the global share of the market is growing rapidly. The main organisations supplying EHRs worldwide include: AdvancedMD, Inc., Allscripts Healthcare Solutions, Inc., Cerner Corporation, Computer Programs and Systems, Inc., CureMD Corporation, eClinicalWorks, Epic Systems Corporation, General Electric Company, Greenway Health, LLC, and Quality Systems, Inc.[79] Nguyen et al. noted in 2014 that there would be an estimated increase in the implementation of EHRs in North America,

by 9.7%, in the Asia Pacific region by 7.6% and in Europe, Africa and Latin America, EHR adoption will increase by 6.6%. In 2010 the market value of EHRs/EMRs was estimated at $15.5 billion and is projected to grow to $19.7 billion.[17] The market share is projected to continue to grow in the coming years.

2.6 Advantages and disadvantages of the EHR

The digital world has evolved greatly in the last two decades. Over half the world's population are now online and two thirds of the world's population have a mobile phone.[80] The requirement for data has changed. The move towards EHRs has allowed massive amounts of data to be captured and now we must use this data and turn it into knowledge.[81] Data is available for use by numerous people across one organisation, in the same instant. The data can be easily accessible and can be manipulated in a number of ways for clinical reasons, audit, research, management and financial planning.[82]

There are advantages and some disadvantages of the EHR, the advantages include: timeliness, availability, completeness, legibility and (ideally) accuracy. Potential improvements in population health include EHRs ability to organize and analyse a large amount of patient information.[83] The cost of storing and accessing paper charts can be a financial burden on organisations. Disadvantages of the EHR include the disruption to workflow as the EHR is being implemented, negative emotions, medical errors and overdependence on technology.[31] For the patient, security measures need to be put into place to ensure that data breaches do not occur. The technology allows for data to be shared across different platforms hence the structure is more susceptible to data breaches.[84]

2.7 eHealth Strategies

A consistent national approach has not been taken for the implementation of EHRs. Countries have either taken a national approach, or EHRs have developed for a medical centre or medical organization. The approach taken usually depends on how the healthcare service is provided and how it is paid for. Several countries have had varied success with the implementation of EHRs. In the United States, a national approach has not been adopted and EHRs or EMRs vary from state to state or medical centre to medical centre. US Government incentives have

attempted to increase the development of the EHR. The Health Information Technology for Economic and Clinical Health Act part of the American Recovery and Reinvestment Act of 2009 was signed into law and gave greater incentives to hospitals and healthcare facilities to use health information technology. The adoption of EHRs has been slow and issues cited have included: implementation issues, optimisation issues, interoperability and cyber security.[83] The United Kingdom initiated a project in 2002: National Programme for Information Technology. This project attempted to create a national health record system for the entire UK. The project however was unsuccessful due to overambitious timescales, poor user experience and the growing cost.[83] The lesson learned for the UK was that a country's size and current health system does influence the implementation for the project.

The French government had varied success with the implementation of the EHR and after the initial unsuccessful attempt a small working group was formed to advise on the programme continuation. A new policy was implemented in 2013 and passed through legislation in 2016. The DMP (Dossier Médical Partagé/ Personal Medical Record project) is a patient centred EHR that allows the patient to interact with the record. The idea of the DMP is that it remains under the control of the patient.[77]

The World Health Organization engaged with the advancement of the eHealth / EHR by providing a national eHealth strategy toolkit for governments and countries to develop a structured comprehensive guide for eHealth for patients.[85] Ireland like many other countries produced an eHealth strategy. The strategy published in 2013 outlines the Irish Health Service Executive (which provides public health and social care services to anyone living in Ireland) and the Irish Government's Department of Health eHealth goals. The purpose of the strategy was to demonstrate how the individual citizen, the Irish healthcare delivery systems - both public and private - and the economy as a whole could benefit from eHealth.[82]

The strategy aims to outline how the proper introduction and utilisation of eHealth will ensure:

- *"The patient is placed at the centre of the healthcare delivery system and becomes an empowered participant in the provision and pursuit of their health and wellbeing.*
- *The successful delivery of health systems reform and the associate structural, financial and service changes planned.*
- *The realisation of health service efficiencies including optimum resource utilisation.*
- *Ireland's healthcare system can respond to the challenge defined by the EU task force report - Redesigning health in Europe for 2020 - to ensure that in the future all EU citizens have access to a high level of healthcare, anywhere in the Union, and at a reasonable cost to our healthcare systems.*
- *The potential of eHealth as a driver for economic growth and development can be realised*."[82]

The strategy document outlines how other countries have implemented eHealth projects and it also provides an economic impact analysis. The strategy document acknowledges that an ageing population and the need to restructure the Irish healthcare system provides challenges to reaching its overall goals.[82]

2.8 EHRs in Ireland

The Maternal & Newborn Clinical Management System (MN-CMS) project is the design and implementation of an EHR for all women and babies in maternity services in Ireland. [86] This is the first national project undertaken in the Republic of Ireland to implement an EHR. The clinical lead for obstetrics of the MN-CMS project outlines the objectives as:

- Implementing a fully integrated maternal and newborn clinical management system to support the business and service objectives of the Hospital.
- Phasing out of the paper chart into the EHR
- Integrating the EHR with all required 3rd party systems
- Implementing the necessary infrastructure to support the project.

- Training all staff required to use the system in an appropriate manner
- Maintenance & Support.

The Maternal & Newborn Clinical Management System national project team recorded their key findings in their phase one closure report. The report was authored by key members of the project team of the MN-CMS. This essential report outlines the stages of phase one including lessons learned and key recommendations for the next phase of the project. This report will be summarised below highlighting key elements that can be used widely. The national obstetric lead provided anecdotal evidence of phase one of the project.

Planning a national system using Maternal & Newborn Clinical Management System (MN-CMS) as an example, including the lessons learned and barriers experienced.

For the MN-CMS programme, a board was set up with the aim to develop a national obstetric and neonatal record for all women and babies in Ireland. The board comprised of stakeholders from the Institute of Obstetrics and Gynaecology, the Faculty of Paediatrics, Nursing and Midwifery staff, Pharmacy personnel, Department of Health personnel, Healthcare IT, and healthcare managers. As the project progressed other stakeholders were recognised and invited to participate these included general practitioners, anaesthetists. The main aim of the board was to provide oversight to procure an EHR This was the start of a change-management project across the maternity services in the Republic of Ireland. The project was greater than an IT project as it included changes across all aspects of maternity services. This project involved moving all maternity units over time to one linked EHR. The project included moving from predominantly paper oriented hospitals to electronic hospitals. The principles set out by the board ensured that the mother and baby were at the centre, information would be collected once only and that the EHR would record practice, not decide practice.

The first step for the board was to carry out a needs assessment. A group comprising of members of the board and senior healthcare managers carried out the needs assessment. The assessment included the 19 maternity units in Ireland

and following the assessment a detail design specification was carried out. In 2011 the public procurement process was commenced, and contracts were signed in 2014. Cerner was chosen as the preferred vendor and the MN-CMS team initiated the implementation programme in 2014.[87]

The MN-CMS national board ensured that a governance structure was in place to guarantee a successful roll-out of the service. The governance structure is outlined below. The rollout (phase one) initially took place in four units from 2016 and will continue with five units per phase.[87] There is not an end date specified as the completion of the project is determined by the availability of public funding.

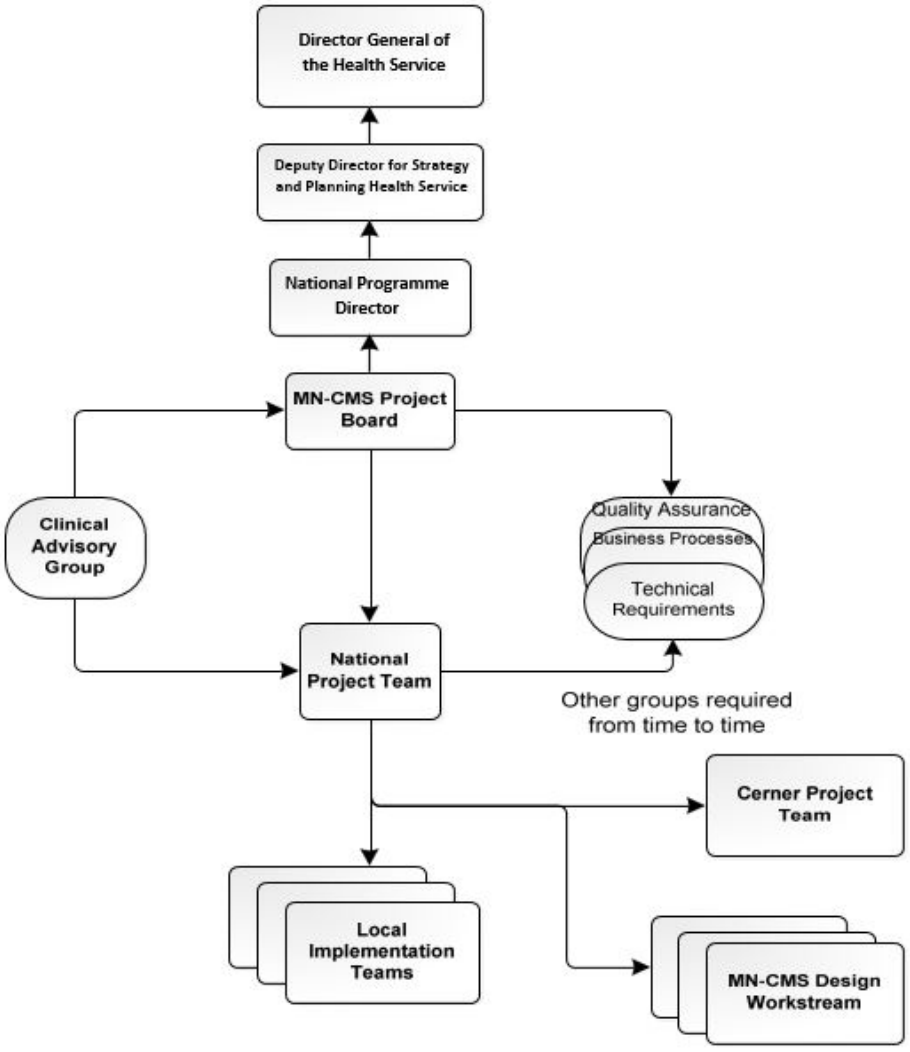


Figure 2.1: MN- CMS Governance model for the development of the EHR

Table 2.1: Suggested key points for the planning phase of an EHR

- Engage key stakeholders early in the process
- Strong leadership including clinical leadership is needed for decision making
- Take time for the procurement process
- Set up a governance structure
- Communicate with staff about the project and engage with interested parties
- Remember to always keep the patient at the centre of the project

Implementing a national system using Maternal & Newborn Clinical Management System (MN-CMS) as an example, including the lessons learned and barriers experienced.

After the contracts were signed the board set-up a project team. This project team had responsibility for the implementation of phase one of the rollout. Clinicians were at the centre of this team and were instrumental in all elements of the project.

The team included the following personnel:

- Programme manager
- Clinical Director
- Neonatal Lead
- Obstetric lead
- Order Communications lead
- Business Implementation managers x2

As the project progressed Local Project Managers usually at midwifery management level were appointed in each of the four initial maternity sites. In each unit a Local Implementation team was established. A workstream was set up for each clinical area. These workflows included aspects of care such as the Booking Visit, Elective and Emergency Caesarean Section Workflows, Stillbirth and Neonatal Death, Blood Transfusion and NICU admission.[87]

The implementation stages included:

- Current state analysis - The workstreams working with the national project team and Cerner completed a current state analysis of the existing workflows in each Hospital. All workflows were mapped from the first phase one units. This included mapping the patient journey from the first referral to the hospital for care to the discharge process following delivery. Between the Maternity and NICU work streams on average approximately 54 workflows were mapped by each hospital. [87]

- Future State analysis - The current state analysis was used to provide a starting point for the Future State analysis - workflows in the new electronic environment. All workflows were considered and a design was based on best practice across all sites using multiple multidisciplinary workstreams.[87]

- Design & Build – A collaborative approach was taken for the design and build phase, this saw the national project team, the vendor and the workstream personnel working together. This phase of the project proved challenging due to the complexity involved in designing and building a comprehensive EHR and as the workstreams had representatives from all 19 units. The recommendations made were fed back to the national team and the vendor. A smaller group made up of clinicians and subject matter experts made final decisions on the design and Cerner then completed the configuration and build.[87]

- Future State Validation – At the end of the design and build phase the project was presented by the national project team and the workstream personnel to maternity services staff. It was an opportunity for attendees to get some hands-on experience of the system and gain an understanding of how it would work in their hospital.[87]

- Design changes - Once the design & build phase closed, there were strict change control protocols put in place. Weekly meetings are held to manage and review change requests. As multiple users are and will be using the system one change for one unit may not be acceptable in another, all changes need to be agreed by all units before being implemented.[87]

- Testing - The testing phase included system testing & integration testing. System testing involved testing the system against the workflows to ensure the design was functioning as expected. Test scripts were created to test the various scenarios that might occur for both the mother and the baby. Integration testing included the interfaces to the third-party systems (system demographics) & laboratory systems (orders and results). The test phases happened in each Hospital as the workflows needed to be validated and to ensure the third-party systems in their individual sites functioned as expected. Integration testing also included the testing of wristbands, bar code scanners and the printing solutions. Device association for the neonatal monitors and ventilators and the fetal monitoring (Cardiotocograph monitoring) solution - FetaLink (FetaLink provides a graphical display of the relationship between fetal heart rates and contraction data in the EHR. It displays waveforms and annotations, which can be viewed in real-time by care providers in inpatient or outpatient settings were all tested during this testing cycle. The Downtime System Access Viewer (7/24) used to view the patient chart in the event of a planned or unplanned downtime also had to be tested at each site.[87] Testing issues were logged to an online portal open to the project team and provider, they were rated with respect to significance (P1 – P5; P1 &P2 needed a fix for go-live) and re-tested and closed when fixed and functioning.

- Local Infrastructure deployment - The additional infrastructure required to implement MN-CMS included computers on wheels, desktop computers, electronic whiteboards, printers, scanners, barcode readers, etc. The purchase of these items had to follow the procurement process. Prior to the deployment of the hardware a WiFi connectivity survey was completed and the extra

power points, data cables and ports required for the new hardware was installed in each unit. The procurement process for hardware was a multidisciplinary exercise involving IT, Biomedical Engineers, End Users and infection Control Teams.[87]

- Training – 2,500 staff across the four phase 1 sites benefited from training of 1-3 days' duration depending on their system role. Course material was prepared, the train domain was populated and following a train the trainer programme, training was provided to staff in each hospital by their peers. The trainers localised their training plans for their specific hospitals and kept detailed training records to ensure that all staff attended training.[87] A small group of multidisciplinary staff were trained as trainers, they gave initial intense training to a larger group and superusers (available for the early weeks of go-live to support colleagues in each clinical area) and then provided the training for all staff with assistance from the superuser group.

- Go-live – The go live phase involved setting up of user accounts, deployment of passwords, data migration and the manning of a 24x7 command centre to support staff over the go live weekend and the post go live early life support (ELS) period. Each Go Live was supported on the ground by the members of the National Project Team, the vendor, team of engineers and solution specialists and the Project Managers and staff from the other sites.[87] Data migration was undertaken for all patients close to term and for inpatients (women and babies) who were expected to remain for a period after go-live. If delivered and documented on paper before go-live, they remained on paper. Patients who attended in labour after the go-live time had delivery documentation done on the EHR and completed their care on the EHR with appropriate agreed data documented including (past history, allergies, medications, risk factors, etc. There was a 'wash through' period before all paper records were removed. The go-live was a big bang, done over a weekend to allow phased introduction of the EHR to inpatient care, then outpatient care after the weekend.

- Medication Management - EHRs and electronic medicines management offer potential to streamline patient care and to engineer safe medication use processes. Currently implemented Clinical Decision Support functionality includes allergy checking, interaction checking, dose range checking, customised rules, weight-based dosing, prewritten order sentences and care plans. Electronic prescribing has been demonstrated to promote safe and effective prescribing practices and to reduce the risk of errors. The system facilitates clinical pharmacy services which have been demonstrated to improve patient outcomes and reduce the risk of serious patient harm.[87]

Table 2.2: Suggested key points for the implementation phase of an EHR

- Ensure multidisciplinary team (especially senior medical staff) involvement as early in the process as possible and tailor the involvement for each staff member
- Spend time developing the workstreams to ensure they cover the necessary aspects
- Limit the changes required to the system and control the changes required with a weekly meeting
- Go live: is when it will show what works and what can be improved
- Remember to keep the patient at the centre of the project at all times

Optimisation of a national system using MN-CMS as an example including the lessons learned and barriers experienced.

- Risks and enhancements – The MN-CMS project team spent time developing the medication management element of the EHR, including clear order sentences with correct formulation dose etc. Medication errors were highlighted early post go live as a key area that could be improved to enhance patient care. Enhancements such as the development of care plans, weight adjusted dosing among others led to safer prescribing.

- Documentation – There are reductions in documentation time which should allow for better records. Staff do not have to duplicate records to the baby chart from the mothers and this saves time. All telephone consultations can be easily and clearly documented as part of the record. With ongoing optimization and training, staff can be assisted in the efficiency of their documentation.[87]

- Data Quality – Routine data collection needs to be simple, clearly defined and an integral part of normal care and the responsibility of all healthcare staff. The need for high quality data was recognised early. Data quality personnel were put in place to check for data errors. Local information governance teams were set up to ensure the integrity of the data. The National Project team also has an Information Governance Group to deal with issues at a national basis for a single national system.

- Reporting – The MN-CMS now has the capability of producing clinical reports for audit, research, financial and management requirements. These reports have taken time to build and test however they will be an invaluable data source in the future. The reporting function is highlighting data quality issues. Processes have been put in place; these include the employment of data quality staff, daily data quality checks that highlight where issues arose from these checks, staff are then contacted and requested to complete the data they have omitted. Ireland's maternity service will have a high quality database contributed from normal care documentation to assess the quality of that care.[87] Demographic information for all patients will be easily accessible and data that would not have been available before will now be available. Routine data collection needs to be simple, clearly defined and an integral part of normal care and the responsibility of all healthcare staff.

- Patient involvement – MyHealthPortal is to be a national online site designed for use by patients and their care givers. Its purpose is to engage patients in

self-care and empower them to take a more active role in their healthcare management. This element of the MN-CMS project has not been set-up to-date. The aim is to have access for patients to the health portal in the near future. For the duration of their pregnancy patients did have access to their paper medical charts. The MN-CMS board are committed to ensuring patients have this access again.[87] This element is key as internationally, there is a drive towards providing Patient accessible EHRs (PAEHRs).[88] However there are limiting factors that include concerns about security and privacy , legal constraints and low uptake of other online resources for patients.[50]

- MN-CMS trainers are an invaluable support to the local project teams and to the end users on the ground. Since Go Live the four sites have engaged with their end users in optimisation sessions where new, advanced, and updated functionality has been taught. The training of new staff and locum doctors is carried out throughout the year.[87]

Table 2.3: Suggested key points for the optimisation phase of an EHR

- Ensure optimisation teams are in place before the project goes live
- Keep your go live trainers involved to increase the functionality and optimisation of the chart
- Ensure an information governance structure is in place for all data requirements
- Ensure staff have mechanisms to feedback about the EHR: staff survey, feedback clinics
- Ensure patient access to their records via a patient portal
- Remember to keep the patient at the centre of the project at all times

2.9 Conclusion

Globally the overall implementation of EHRs has not been as successful as it could of have been. However, there is evidence that there are a number of benefits e.g. medication errors have been reduced, and concurrent/remote access to patient

records allows for more effective, efficient and safe care. Healthcare is an extremely complex environment and there are lessons it can learn from the digital transformation of banking, finance, transportation, navigation and retail. The healthcare community can utilise the EHR to bring the same type of changes to healthcare.[89] This chapter highlights an EHR development as an example of a clinician led, patient focused, change management project. The project team ensured patient care was at the core of the development and implementation. The MN-CMS project is now entering phase 2 and this will allow for the project to be implemented across other sites. However, for MN-CMS to continue to grow the initial four units are now in the ever-evolving cycle of the optimisation process to ensure the full benefit of the EHR for care. This task needs to be resourced adequately to allow the chart to really develop and to be used to its full potential. The everyday user needs to be engaged with to see how they are using the EHR, what they find easy and difficult to navigate, the staff are key to the optimisation process. The staff are now the experts in using the system. The MN-CMS project team need to continue their excellent start to the roll-out of MN-CMS. The Irish Department of Health need to continue to resource the EHR development. Ireland has the opportunity to slowly build an efficient, effective EHR that can impact on patient care from birth to death.

The information technology tools for EHRs are developing at incredible speed. Already the use of high-resolution cameras and ultrasound imaging can enhance the patient information in the record. The future for EHRs is fast approaching and new techniques may include vital signs automatically updating into the chart, an automated assistant that would listen to the interactions between doctor and patient and from verbal cues record the information in the exam room.[89] Interactive patient portals will allow patients not only review their data (ensuring accuracy) but also input information prior to consultations and assist self-care as part of chronic disease management. Interoperability will mean the patient and their clinician will have full access irrespective of geography. As EHRs continue to progress, research will be required to examine how the medical profession have adapted to this introduction and how EHRs continue to influence the clinician-

patient relationship. However, the greatest effect on healthcare will come from data science using the information available in the EHR. The potential of the data available in the EHR will make changes to all our lives if it is used correctly. Data protection and regulation laws need to be adhered to. The governance of data is key to the continued success of the development of the EHR. If any EHR project maintains that they keep the patient at the centre of the project they need to ensure the patient data is used effectively. Patients need to be informed of how their data is used, why it is used in a particular way and how it can improve care and conditions for themselves and others. They also need to know their data is respected and entered correctly. Academic institutions have realised the importance of informatics and the importance of data retrieval and they are now providing modules at undergraduate level to prepare medical professionals.[78] The potential value of data science is well recognized in the IT world; Vinod Khosla (2013) suggested that "In the next 10 years data science will do more for medicine than all the biological sciences combined" It is likely that big data will assist us answer questions about the best care that would not be possible if we await the randomized trial approach.

The change from paper to electronic records is a change project requiring a planned approach; seeing it as an IT project dooms it to failure. These projects need real commitment and leadership from the clinical community. We cannot continue to function in clinical care just replacing the written record with the computer, we need to look at our practice making the full use of the new tools provided in the era of the EHR. EHRs are central to modern medical care, supporting the organisation and delivery of sustainable care and offering the potential for joint decision making and involvement in self-care by the patient.

Chapter 3:

Patient experience of the Electronic Health Record (EHR) in a maternity unit in Ireland

McKernan J, Corcoran P, Greene R.

Accepted for publication by the

Patient Experience Journal

Chapter 3: Patient experience of the Electronic Health Record in a maternity unit in Ireland

3.1 Abstract

Background/Objective: The introduction of the Electronic Health Records (EHRs) for maternity services in Ireland provided an opportunity to examine patient satisfaction and to examine what patients require from an Electronic Health Record. The implementation of the EHR in Ireland started in 2016 and at present four of the 19 maternity units are digital.

Methods: Patients at antenatal booking visits in an Irish maternity unit were invited to participate in the project. The invite was taken up by 201 women. The survey took 10-15 minutes to complete. The survey was conducted nine months following the implementation of the MN-CMS. The survey was anonymous and was divided into three distinctive sections; participant information, regarding the staff encounters on their visits and questions about the new system.

Results:

70% of participants rated their overall consultation from very good to outstanding. 73% of participants believe the computer system will ensure quality of care. Participants believe their personal information is safe (65%) in the new computer system. Over 75% of participants did not have any concerns regarding the new computer system. Eighty-one percent of participants noted that they would like access online to their charts and 91% of these respondents would like access to the full chart.

Conclusion

Patients in this study were very receptive to the introduction of EHR and noted that it would be beneficial for their care. They also noted the impact the EHR could have on clinic time and interactions with staff. However, patients require access to their charts this they believe would provide them with ownership of their health.

Keywords

Electronic Health Records, patient interaction, data security, patient portal

3.2 Introduction

Electronic Health Records (EHRs) provide clinicians the opportunity to ensure care is patient centred. EHRs can be accessed at any time by multiple users, they allow data to be transferred easily and provide for a complete overview of the patient, including information from the whole multidisciplinary team. This ensures accurate information is available at the time of all patient interactions. Local policies as well as national guidelines can be accessed through the chart.[90]

The last number of years have seen a digital boom in new technologies in all aspects of life. Communication between patient and the healthcare professional needs to be maintained and in some situations improved. Patients need to feel they have been heard and that they can speak openly with their healthcare professional. Good communication between healthcare professionals and patients can lead to a greater adherence to treatment and improved clinical outcomes.[91] The EHR may have changed the dynamic of the exam room but it has not changed what people expect.[92]

The definition of patient satisfaction is complex and in particular for the pregnant population. The Consultation and Relational Empathy (CARE) Measure has been extensively validated and is widely used by doctors in primary care. This model was adapted for this study.[93]

The introduction of the European General Data Protection Regulation 29 (GDPR) in May 2018 ensures patients have the right to control how their data is used. The public consultation for the introduction of GDPR noted that citizens want greater access to their data and wish their data to be available for treatment and research if appropriate safeguards are put in place.[94] This requires IT infrastructure to be developed in conjunction with data protection rules to ensure citizens have the right to access and share their health data.[90]

The introduction of the Electronic Health Records for maternity services in Ireland provided an opportunity to examine patient satisfaction and to examine what patients require from an Electronic Health Record. The implementation of the EHR

in Ireland started in 2016 and at present four of the 19 maternity units are digital; the remaining hospitals will go live in a phased manner.

The computer and the use of the computer by the healthcare professional can be seen by some patients as a barrier. The patient may be reluctant to ask questions or voice concerns regarding their care.[94] Street et al examined thirty-two physicians and 217 patients with a mean visit length of 20.3 minutes, found that physicians clicked the mouse 216 times and spent 8.9 minutes gazing at the screen. At times the clinician may feel under pressure to collect all the data required. They may spend time typing and looking at the screen, altering the doctor-patient interaction; they may then be reluctant to express concerns or ask questions.[95] Although the implementation of EHRs requires time, issues arise due to the complexity of the data, data entry errors, IT security and confidentiality concerns.[15,96] Clinician's acceptance of the EHR is important and these key personnel should be highly engaged in the implementation process. Ensuring the staff are kept motivated with prompt feedback and high-quality support contributes to the overall satisfaction of the implementation and thus leading to an overall better patient experience.

Providing patients with access to their health records online has been debated in detail. Research has shown that there are positive benefits to the patient's experience; however, many healthcare professionals still have a number of fears regarding patient access.[50] These fears include the erroneous interpretation of the results by the patient without clinical input. Security concerns regarding how and who can access the data raises concerns for the staff. [97] Maternity patients in Ireland had access to the paper records before the introduction of the EHR. A considerable amount of time was given to speaking with patient representatives regarding the removal of the paper record from the women. This decision was not taken lightly as it is known that women report a greater understanding and a feeling of control when they have access to the health record. Carrying the notes gave women confidence, ensured accuracy of the information and made them feel in control of their own health.[90] Taking these key elements into consideration the

aim of this study was to assess patient satisfaction and to examine perception of the introduction of the new EHR.

3.3 Methods

Pregnant women attending antenatal booking visits in an Irish maternity unit were invited to participate in the project. These women were either attending their first booking visit to the hospital, or any of their appointments between 12 to 39 weeks of their pregnancy. Approximately 230 women were approached to participate in the project. The questionnaire was administered 9 months following the implementation of the MN-CMS in 2016. The survey was a paper-based survey and was conducted by the researcher. The questionnaire was completed by a sample size of 201 patients (women) aged over 18 years. The questionnaire took 10 -15 minutes to complete. The researcher administrating the survey timed the participants to see how long the survey took to complete. This was an important element when requesting people to participate in the study. The questionnaire was anonymous and was non-compulsory. It was divided into three distinctive sections; participant information, questions based on the Consultation and Relational Empathy (CARE) Measure and questions about the new system. Information about the study was provided to the participants.

The CARE Measure is a person-centred process measure. Dr Stewart Mercer et al. at the Departments of General Practice in Glasgow University and Edinburgh University originally developed the CARE measure. The scale comprises of 10 questions measuring empathy in the setting of the therapeutic rapport during a one-on-one consultation between a clinician and a patient.[93,98] For the purpose of this project, a modified version of the CARE measure was used. This was decided because of the population completing the questionnaire. Aspects of the questionnaire for example feeling positive and helping you take control were two questions removed from the questionnaire. For this project we used a 7-point Likert Scale ranging from 'poor' to 'outstanding', generating values between 1 and 7. Overall satisfaction was rated on a Likert scale (from 1 = completely satisfied to 7 = completely dissatisfied).

One-way analysis of variance (ANOVA) was used to compare mean levels of satisfaction between more than three groups, e.g., first-time mothers, women who already had a baby in the unit, women who already had a baby but not in the unit. (Appendix II: Supplementary table 1)

The Cork Teaching Hospitals Ethics Committee, University College Cork, granted ethical approval. Descriptive statistics were reported, and all analyses were performed with SPSS 20.0 software (SPSS, Chicago, IL).

3.4 Results

A total of 201 questionnaires were collected at antenatal visits. Over 90% of respondents had visited the clinic more than once. Participants were asked a series of questions regarding the staff they encountered on their visit.

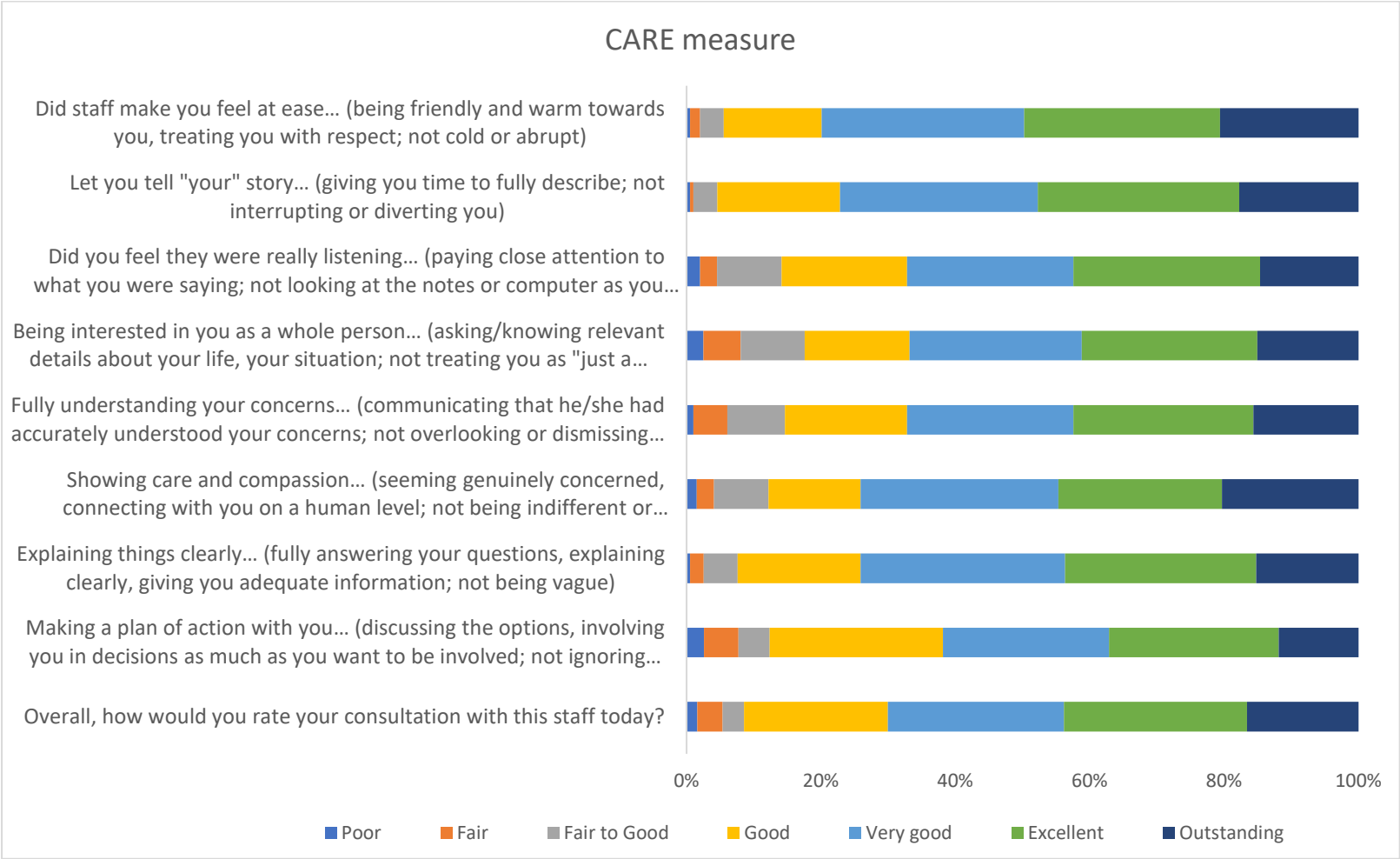


Figure 3. 1:The Consultation and Relational Empathy (CARE) Measure

There was no variation in mean satisfaction score between first-time mothers, women who already had a baby in CUMH, women who already had a baby but not in CUMH (p-value=0.939).

Mean satisfaction differed by 'Q16, specify' (p-value<0.001). Those who said yes to Q16 were, on average, more satisfied. Their average score was 6.9 (16%) higher than those who said no to Q16.

Mean satisfaction differed by 'Q17, specify' (p-value=0.024). Those who were not sure with respect to Q17 were, on average, less satisfied. Their average score was 5.4 and 6.3 lower than those who said yes and no, respectively.

There was no notable variation in mean satisfaction score between women who responded differently to Q18 (p-value=0.860), Q19 (p-value=0.526), Q20 (p-value=0.386), Q21 (p-value=0.314).

Overall, the participants were positive about their experience; 70% (n=81) of participants rated their overall consultation from very good to outstanding. The question that showed the most varied responses asked if participants felt staff were interested in them as a whole person …(asking/knowing relevant details about your life, your situation; not treating you as "just a number"). A reliability analysis was carried out on the perceived task values scale comprising of nine items. Cronbach's alpha showed the questionnaire to reach acceptable reliability, $\alpha = 0.97$. All questions appeared to be worthy of inclusion.

The second section asked participants to comment on the new system. Over 53% of staff explained their use of the computer to participants. Nearly 60% of participants felt their consultation had not been altered by documenting it on the computer system. Nearly 83% of participants felt the efficiency of the clinic will be improved by the computer system and 73% of participants believe the computer system will ensure quality of care. Sixty-five percent of participants believe their personal information is safe in the new computer system with only about 5% noting they would feel in wasn't safe others felt they didn't know. Over 75% of participants did not have any concerns regarding the new computer system.

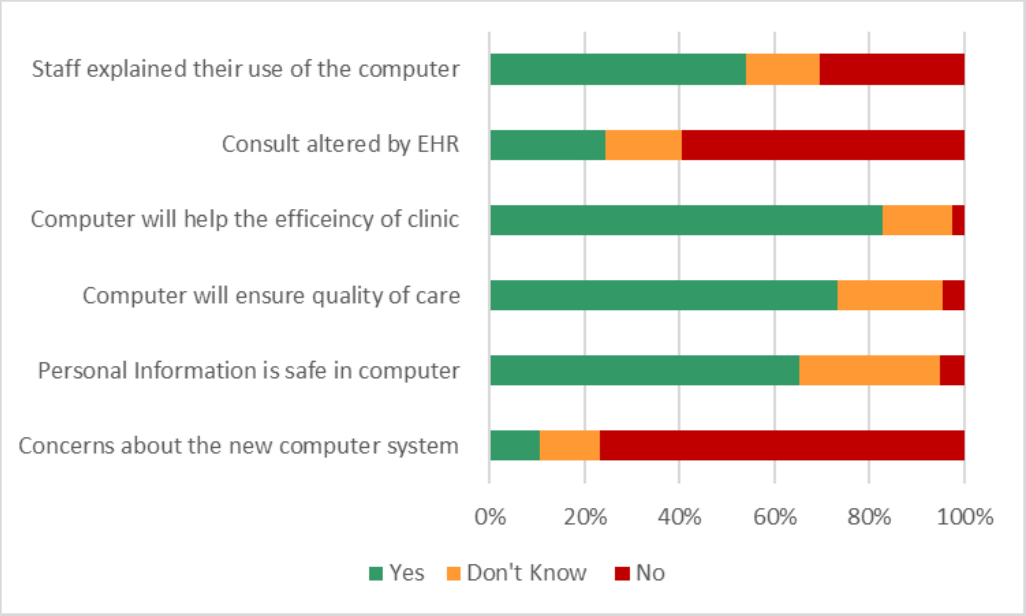


Figure 3.2: Patient views on the implementation of the new system

Participants were asked if it would be helpful if more information was available regarding the computer system. Over 51% of participants felt this would be helpful and responded that the most helpful way to receive this information would be by leaflet (75%), from staff (67%), from their GP (55%) and 45% suggested at antenatal classes. The majority (81%) of participants noted that they would like online access to their charts and 91% of these respondents would like access to the full chart. One participant noted *"Yes I think it is important to be able to have access to my notes after all the information is about me and I have a right to know what's going on".* The themes that emerged from the women attending the clinic included access to the their chart, new staff and the new system. The comments were complimentary of the staff and the service they provide but at least 15% of the women commented that the clinic should be run more efficiently with the introduction of an electronic system. *"Make sure every patient is listened to carefully about their previous birth deliveries, making sure the patient best interest comes first. Any complications that have not been recorded that the staff know that the patient knows more about her health than anyone."* Some patients noted that more training is required as it had an impact of their appointments and clinic times. *"I think more training needs to be given to staff on how to use the database. My appointment went on for nearly 2 hours as the member of staff clearly did not know how to use it. It was like keep clicking the mouse and hoping something*

would happen on numerous occasions. I actually took the mouse off her. In the end she had to get another member of staff."

3.5 Discussion

The introduction of EHRs is a complex change management project that requires the patient to be at the centre of the development of the project. [15] The results of this study are divided into three sections. The first section examines how satisfied the patient was with their visit. This information is important to capture as it provides knowledge of the perception the patient had of the staff they encountered. The patients were asked a series of questions that showed how they rated the staff. In this study over 80% of patients rated feeling at ease from very good to outstanding. The move towards patient focussed care is becoming more and more prominent. The core element of the care model is to have the patient at the centre of the care. For patient centred initiatives, it shows that patients' satisfaction with their physician is a marker in health care; it allows for patient compliance and may lead to better health outcomes.[99]

Patient satisfaction is now key for healthcare providers and it is a focus for the industry to examine the quality of the healthcare services.[90] The aim for all healthcare providers should be to mark highly in this area. The elements of listening, making a plan and understanding are indicative of how the healthcare professional and the patient are interacting. Over 40% of participants felt their encounter was altered by the use of the computer system – this ranged from the length of time (felt shorter for the patient) that the patient was seen by the clinicians and the clinicians use of the chart. The HealthCare Professional (HCP) use of the EHR may lead to the patient's reluctance to express concerns or talk as the HCP is typing or looking at the screen.[100] Patient access to their records was a significant finding in this study with patients wishing access to their electronic record was mandatory. Maternity patients feel a level of control having their notes and this study found that 91% of participants would like full access to their charts. The perception that this is their data was very evident amongst participants. Due to the introduction of GDPR and a greater awareness of the right to access their data and their wish to access the data, there is an urgent need to provide such access, optimally to the whole record. Access to data will be available to patients

in time and a consultation process is required to examine what level of access is considered appropriate by the patients. There is limited evidence to show that patient access to charts improves health outcomes and at times patient access is not met with enthusiasm by the HCP.[101]

This introduction of the EHR in maternity services in Ireland is a first step in the introduction of a complete EHR. This study shows that patient satisfaction is at a high level with the introduction of the EHR. Further work is needed to examine the benefits of patient access to Electronic Charts. Studies are also required to examine the level of access, appropriate for patients, this may be the complete record in pregnancy but different in other areas of healthcare. Public health education programmes may be required to inform patients of the information held and the reasons for same and to assess how much of it they wish to access. Further research is required to work with patients regarding the interpretation of information, how they wish to input data including health literacy projects. Data can be provided in two ways; the patient may have view only access or be more interactive inputting information to their notes (to be endorsed for final inclusion after discussion with the HCP) asking for advice, assistance, booking their visits via a portal.[101]

Patients can further provide feedback regarding their experience with the healthcare professionals and the services they encountered.[102] A well planned and well-resourced patient portal may provide the complete picture of care with patients at the centre. Taking steps to set up the patient portal with the patients involved in the development may remove the possibility that patient access to the EHRs causing anxiety and worry for the patient about information they access.[50] This emerging area of EHRs needs to be examined both qualitatively and quantitatively. This development can allow for researchers to join with IT and clinicians to develop a change management project to transform how patient care is provided. As EHRs become embedded in healthcare systems there is a move towards an integrated approach for the collection of patient reported outcome measures (PROMS). It may be a challenging for the healthcare system however there are many benefits for patients and healthcare providers. The benefits

include improvements to patient care, shared decision making and patient focussed research.[103] The core element of this project is the patient-HCP communication. Frameworks may be followed to allow for improvement and analysis of communication.[99]

3.6 Strengths and Limitations

Our study had several strengths, one of these strengths included the validated survey tool, it is recommended that the minimum of 200 subjects allows for a reliable factor analysis.[93] We were able to achieve this number. The study provided us with a unique opportunity to engage with patients at the implementation phase of the MN-CMS. We gathered information that showed what patients needed. One limitation of the study is that we may have been able to open it up to a wider audience and move the study online.

3.7 Conclusion

Patients in this study were very receptive to the introduction of EHR and noted that it would be beneficial for their care. They also noted the impact the EHR could have on clinic time and interactions with staff. However, patients require access to their charts; they believe would provide them with ownership of their health. If patients have access to their charts the ability to complete their data before booking visit and subsequent visits this would free up time to allow for meaningful patient engagement. Patient satisfaction plays a key role in the further development of the EHRs as one component of healthcare. For some countries merging the patient portal element and the implementation of the EHR may allow a complete patient centred chart to be developed. Further research is required to examine how patients should access the chart and the information they have access to. Communication between the HCP and patient is key to any development.

Chapter 4:
Examining the implications of the implementation of an Electronic Health Record on staff: lessons learned

McKernan J, Corcoran P, Ayodeji,O, Greene R.

Submitted to the Journal of the Society for Clinical Data Management

Chapter 4: Examining the implications of the implementation of an Electronic Health Record on staff: lessons learned

4.1 Abstract

Background:

The EHR provides many benefits across clinical, organisational and societal outcomes. Clinical advantages of EHRs include reducing the risk of error, promoting safe practice, and enhancing communication among staff and between patients and multiple providers. There are key elements to consider when undertaking an implementation project. The introduction of the EHR for maternity services in Ireland provided an opportunity to examine staff perceptions of the EHR and to examine the staff primary concerns.

Methods

For this project we carried out a pre-implementation survey, a post implementation survey, and a post documentation audit. The post implementation questionnaire was divided into four distinct sections: general demographics, EHR usability and usefulness, primary concerns, documentation and EHR support.

Results

Staff members were asked to comment on their experience and four themes emerged; these included: issues with logging into the system, training requirements, improvement in-patient care, and documentation. Staff commented that documentation had improved and was now legible however there were still issues evident. Nearly 60% (n=100) of participants were happy with the implementation of the EHR and 50% (n=82) believed they were operating at the full extent of their education and 72% (n=106) believed their personal productivity had returned to normal. Audited charts we found compliance to be at 90% for all chosen data variables. We expected missing data in the reports to be at 5%; for the breastfeeding report it was at 6.5%, the labour ward report was at 10% and the neonatal admission report was at 9%. Overall data completeness

was high in most variables and the missing variables may be improved with training plans.

Conclusion

Staff are a crucial element in the implementation of any EHR system. This project provided an opportunity to highlight the complexity of implementing an electronic health record for staff. It showed that to truly understand the adoption of an EHR, innovative techniques are required to show how staff rate the success of the implementation.

Keywords

Staff members, EHR implementation**,** EHR usability and usefulness, primary concerns, documentation and EHR support

4.2 Introduction

There is evidence to suggest that Electronic health records (EHRs) will transform healthcare systems, improve documentation and provide an endless supply of clinical data.[104,105] The EHR provides many benefits across clinical, organisational and societal outcomes.[31] Clinical advantages of EHRs include reducing the risk of error, promoting safe practice, and enhancing communication among staff and between patients and multiple providers.[106] Organisational outcomes include enhanced financial and operational performance, patient and clinician satisfaction. Societal outcomes allow for an increased capacity for research and improved public health.[31] There are key elements to consider when undertaking an implementation project and the complex nature of the transformation required with EHRs can lead to failure and underutilisation.[48] The users of EHRs are key to the successful transformation; by understanding their engagement with the chart there is an opportunity to enhance success, avoid poor uptake and financial waste.

Understanding the users at the initial stages and as the chart is integrated into everyday practice, allows an implementation team to understand the positive and negative impacts. If elements of the staff requirements are missing, it may lead to the implementation of the project being delayed and moving to the optimisation phase will take longer.[105]

The implementation of the EHR can be a slow process that needs time to show the benefits of improvement. This process needs to be continually evaluated and a clear definition of success is required.[107] The introduction of an EHR does add additional burdens to staff including the perception that communication with patients is affected, that data entry and additional administrative tasks are more onerous.[31] The insights gained from staff are fundamental to allow the development of the EHR project while ensuring the provision of quality care to patients. Staff understanding and adaptation to change has the greatest impact on patient care.[108]

For staff members there are several areas that need to be addressed and reviewed regularly. These include workflows, security, training, and technical support.

Nguyen et al (2014) commented in their review that staff noted both positive and negative impacts transitioning from a paper base to electronic data; they identified that poor quality training leads to poor utilisation of the EHR and the importance of having champions to adoption of the EHR. [17]

Ireland's ehealth strategy highlights that such EHRs could transform healthcare in the country.[82] The implementation of the EHR in the Irish maternity services started in the Cork University Maternity Hospital (CUMH) in December 2016. By 2020, four of the 19 maternity units were digital, and the remaining hospitals will go live in a phased manner. The introduction of the EHR for maternity services in Ireland provided an opportunity to examine staff perceptions of the EHR and to examine the staff primary concerns. Evaluating data from the initial stages and throughout the implementation process allows for policies and procedures to be implemented as the project progresses. This study aims to highlight the staff experience since the introduction of the electronic chart. The CUMH staff had only used paper-based data collection methods prior to the EHR implementation. They did not have any experience of electronic systems; this is a key aspect to this research project and to how the staff reacted to the implementation.

4.3 Methods

4.3.1 Pre-implementation survey

Understanding the implementation of an EHR provides several key findings. One recommended part of the process it to continuously evaluate the implementation. Like many others Bossen *et al* used the Delone and McLean model for information systems (IS) success.[109] This model allows for a mixed method approach to evaluate the implementation.[110] For the purpose of this study, we used a mixed methods approach, under the direction of the research team and as part of their master's degree one of the authors (not the first author of this paper) distributed a questionnaire to staff to examine their level of information technology skills (computer and social media skills) and their motivation to moving to the EHR; these might influence users' expectations for the proposed change.

4.3.2 Post-implementation survey

Following the implementation, we distributed a user satisfaction questionnaire 18 months after the EHR had been implemented. We felt this was a necessary

timeframe to allow staff to get used to the working in a digital environment. The authors examined a number of questionnaires and decided that the adaptation of the Family Practice Management (FPM) Questionnaire of User Satisfaction with EHR Systems would provide us with the most relevant useful information. [111] Edsall, RL *et al* note their aim was to compare EHRs from various suppliers but overall wanted to collect data to convey a clear range of responses that were functional for the user and EHR supplier.[112] The questionnaire is divided into four distinct sections; General Demographics, EHR Usability and Usefulness, Primary Concerns, Documentation and EHR support. This survey allowed us determine user satisfaction with aspects of the EHR by using the scale strongly agree, agree, disagree, and strongly disagree. We also added questions in relation to features that staff felt improved patient care as well as issues that caused problems and their overall experience with the EHR. (Appendix IV) As the roll out of the EHR nationally is on a phased basis one element of the questionnaire that was important to examine was training and training needs. The survey was anonymous, and participation was voluntary.

The CUMH has a staff of over 600 people and clinical staff of about 540 people. The questionnaire was prepared using the web-based questionnaire tool LimeSurvey. A link to the survey was emailed to all staff during June 2019, 18 months after the introduction of the EHR. For Non-Clinical House Doctors (NCHDs) they would have at least 6 months using the system before completing the survey. We sent reminders out regularly and the survey was mentioned at meetings by senior staff to encourage involvement. We also distributed the survey in paper format at senior staff meetings, junior doctor meetings and we distributed paper forms to ward managers. We felt we needed to use this method for distribution as all staff would not access their email regularly. The questionnaire took 15-20 minutes to complete. We had a response rate of 31%, the questionnaire was completed by a sample size of 170.

The Social Research Ethics Committee of University College Cork provided ethical approval for the study (Study approval number 2018-033)

4.3.3 Post-implementation documentation audit

Following the survey roll-out to staff and the analysis of the survey results, the research team undertook an audit of clinical charts to examine the data. The objective of this work was to further examine the issues mentioned by staff. Documentation was mentioned by staff as an area that caused them issues. We carried out this work to examine the impact this was having on the documentation but also to examine if the staff were perceiving difficulties in the workflows. The research team picked key areas of the electronic health records that would have the most impact on the data. The areas examined were the labour and delivery, breastfeeding, pregnancy loss and neonatal admission documentation.

Two methodologies were used; the first involved assessing twenty patient records in the areas of antenatal booking visit, pregnancy loss, breastfeeding activity, labour ward activity and neonatal admission activity; these were audited to examine the appropriate documentation of patients. We choose data fields that are required (for care, reporting and data extracts to national bodies) to be completed and randomly choose 20 charts to check the data. Secondly, we audited the clinical data reports for documentation completeness. This involved us analysing the degree of missing data evident. We examined the completed data from 2018. We were unable to check the booking visit report for 2018. This report has 89 variables, many of the variables used in the report are not pertinent to all women, data completeness is not easy to assess. For example, all patients are asked about smoking with a yes/no answer, other questions would be posed if the answer is 'yes' but not if the answer is no'.

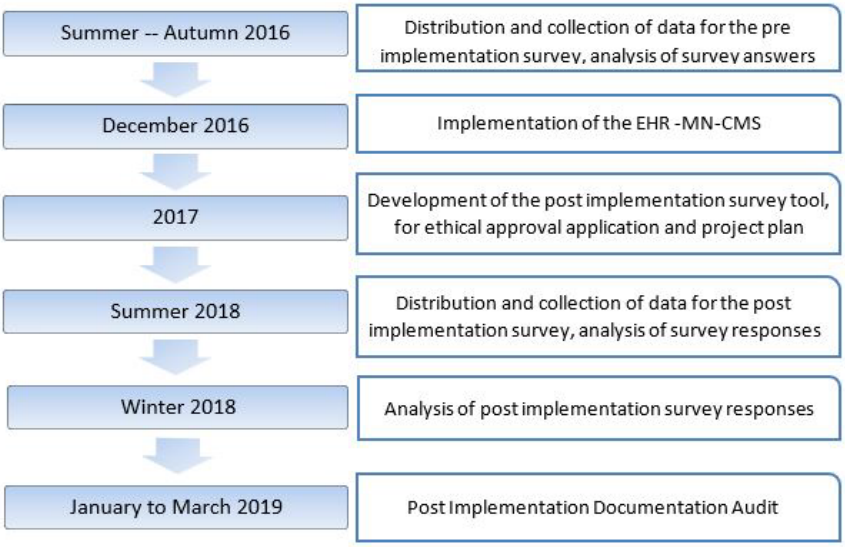


Figure 4.1: Timelines of methodology

4.4 Results

4.4.1 Pre-implementation survey

For the pre-implementation survey 85 staff responded and the majority were midwifery staff. Only 150 staff were asked to participate in this survey. The staff that completed the survey included midwives, midwifery management and junior doctors. Overall, two thirds of the sample respondents showed a reasonable level of motivation towards the introduction of an EHR. Well-informed responders showed a strong level of motivation to the introduction of an EHR, and they noted the benefits included the improvement of patient care. Respondents felt the EHR would improve legibility, reduce prescribing errors, enable multiple user access, and improve communication. However, concerns were expressed regarding adequate training and the respondent's knowledge; overall, there was a positive attitude towards the EHR. A limitation of this study was that we were unable to collect more respondents that may have been more representative of the staff thoughts.

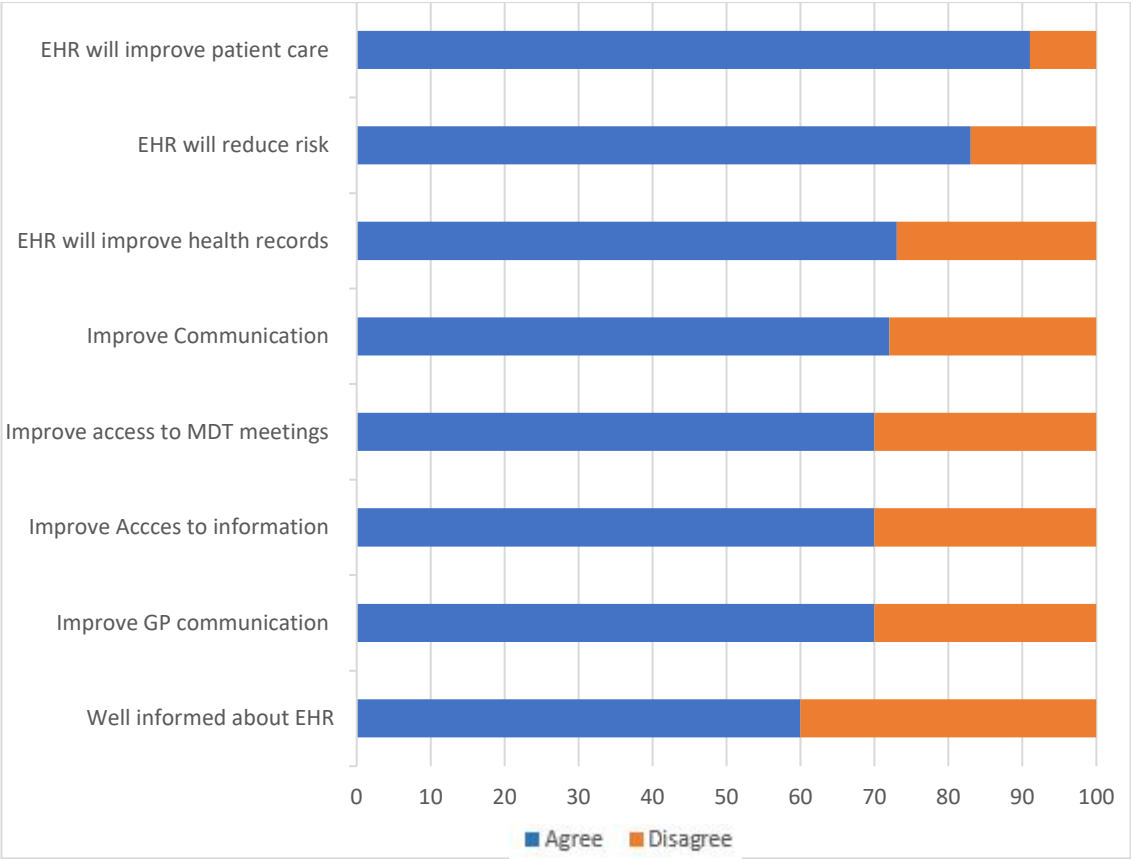


Figure 4.2: Perceptions about the EHR introduction from motivated staff

4.4.2 Post-implementation survey

The post implementation survey was completed by 170 members of hospital staff. Two-thirds were midwives or nurses (n=111, 68%), 12% were midwifery/nursing managers (n=19), 12% were consultant or trainee doctors (n=19) and 9% were in other categories of staff such as administration and allied health (n=14; staff type not recorded for seven respondents). The respondents to the survey are a good representative mix of the staff categories in the unit.

Most respondents had been using the EHR since it was implemented in the hospital (n=100, 62%; not recorded for eight respondents).

The question of whether they would return to a paper-based record was completed by 148 of the 170 respondents (87%). Most who answered (n=84, 57%, 95% confidence interval=48-65%) indicated that they would not return to paper charts.

There was little variation by type of staff in opinion about returning to a paper-based record (p-value=0.406). The majority indicated that they would not go back

to paper - midwives/nurses (57%), midwifery/nursing managers (67%), consultants (67%) and other staff (67%) - but this was not the case for trainee doctors (33%).

Staff who had been using the EHR since it was introduced (since go live) in the hospital were just as likely to indicate that they would not return to a paper-based system (n=53 of 92, 58%) as those who started using the EHR after it was introduced (those who joined the service after the go live) (n=30 of 54, 56%; p-value=0.809).

We examined the training needs of the staff and found that 78% (n= 134) of respondents requested additional training. 42% (n= 73) of respondents agreed that the training provided to them prepared them to perform their duties using the EHR.

Nearly 60% (n=100) of participants were happy with the implementation of the EHR and 50% (n=82) believed they were operating at the full extent of their education and 72% (n=106) believed their personal productivity had returned to normal.

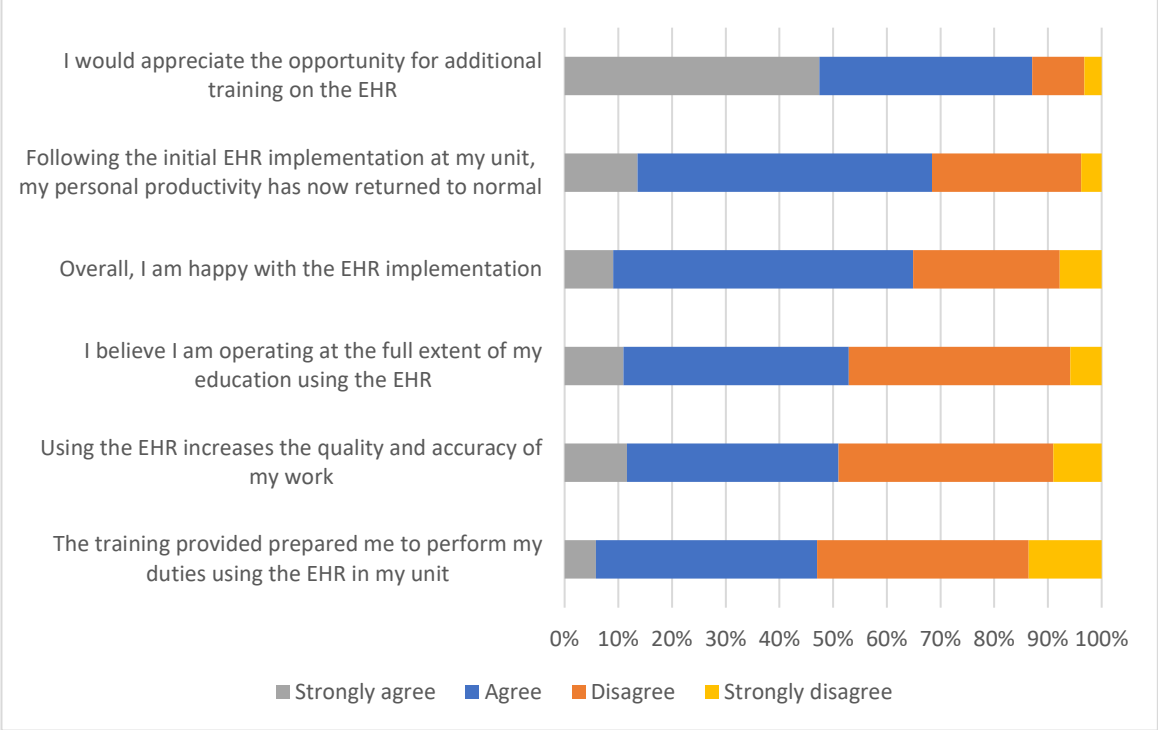


Figure 4.3: Participants perception of the EHR

Supplementary figure outlined in Appendix V outlines the staff perception of the usability and usefulness of the chart. It highlights their ease of finding, searching medications and gives indications of how staff are using the chart as well as how staff navigate this new system. Nearly 80% (n=113) of staff felt confident navigating and documenting while seeing patients. Overall staff showed an ease of navigation as for electronic review as nearly 80% (n=108) were able to respond to patient's diagnostic testing results and 60% (n=82) felt they were able to determine a care plan for a patient from the EHR.

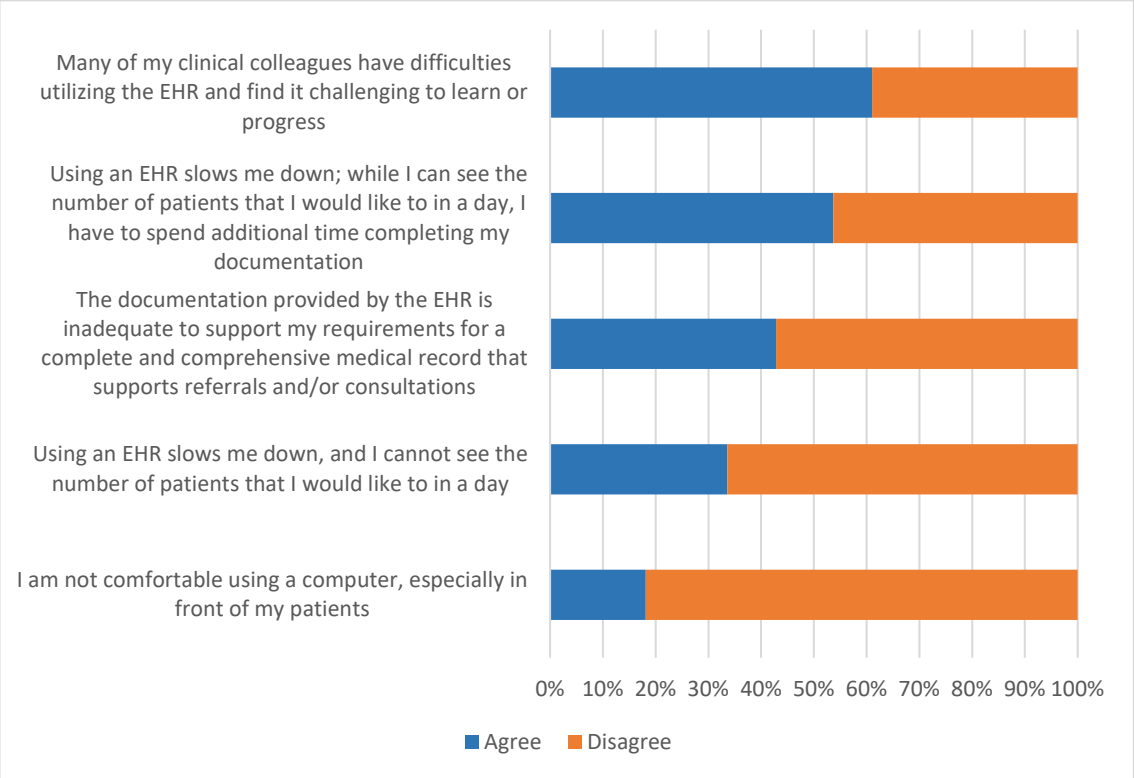


Figure 4.4: Staff Primary Concerns

The staff were asked to agree or disagree from a list of statements regarding their primary concerns and 60% (n=72) of them felt that their colleagues had difficulties utilising the EHR. Nearly 35% (n=39) of staff felt that the EHR slowed them down, and that additional time was needed to complete documentation. 85% (n= 99) of staff were comfortable to use the EHR in front of patients.

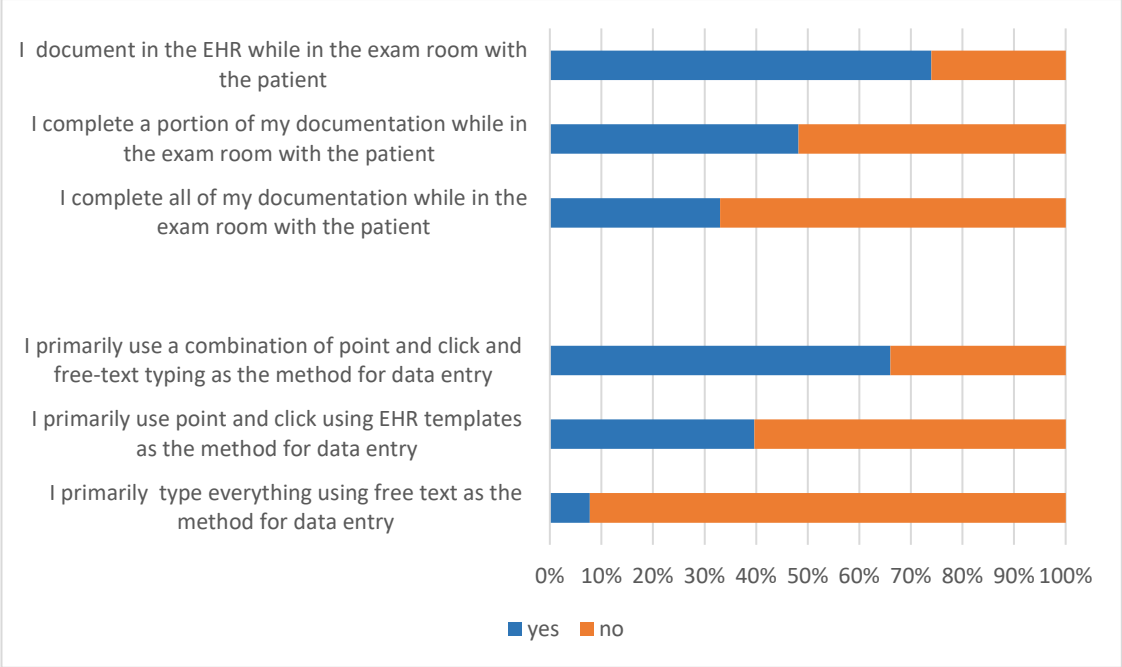


Figure 4.5: Behaviour and attitudes regarding documentation

Staff were asked about their documentation habits and over 70% (n=74) document while in the exam room with the patient however only 30% (n=33) complete all their documentation while in the exam room. Over 65% (n=72) of respondents primarily use a combination of point and click and free text typing. In the EHR the point and click facility covers drop-down boxes and structured data fields. Nearly 50% (n=84) of staff members noted that while documentation may take longer easy access to investigations results had saved time. Forty per cent (n= 68) of staff agreed that the IT department was responsive at the organisation and that they would easily get help when having a problem.

Staff were asked to comment on their experience and four themes emerged; these included: issues with logging into the system, training requirements, improvement in-patient care and documentation.

Table 4.1: Themes and Quotes

Theme	Staff Quotes
Issues with logging into the system	"Having to log in 3 times to access" "Logging in and out frequently is an issue" "Multiple login very slow"

Training requirements	"More training would help" "doctor training is key in correct prescribing and utilisation of powerplans" "More training on the job and not by getting memos every so often when something new is introduced" "more training and more on the ground support staff"
improvement in-patient care	"Speed, Efficiency, less time writing" "many can look at the chart at once." "easy to read plan of care from doctors - no more issues with illegible hand writing" "more time to spend with patients"
Documentation	"Documentation is legible" "Some not charted and signed relying on verbal handover to prevent overdosing patients" "data is directly available on a screen all over hospital" "differences in documentation between staff"

When asked about the overall experience most participants commented that it was challenging and frustrating however it is improving and overall was a positive experience.

4.4.3 Post-implementation documentation audit

Following the results of the survey and regarding documentation and training the research team undertook an audit of data in the charts and data reports generated from the charts.

This purpose of this was to examine the documentation habits of the staff and ensure a focus to future training requirements. In the audited charts we found compliance to be at 90% for all chosen data variables.

For the data reports generated we checked the variables for data completeness, and we checked one variable per report for data accuracy. Overall, we were expecting some missing data in the reports; for the pregnancy loss report it was 8%, for the breastfeeding report it was at 6.5%, the labour ward report was at 10% and the neonatal admission report was at 9%. Overall data completeness was high in most variables and the missing variables could be improved with training plans.

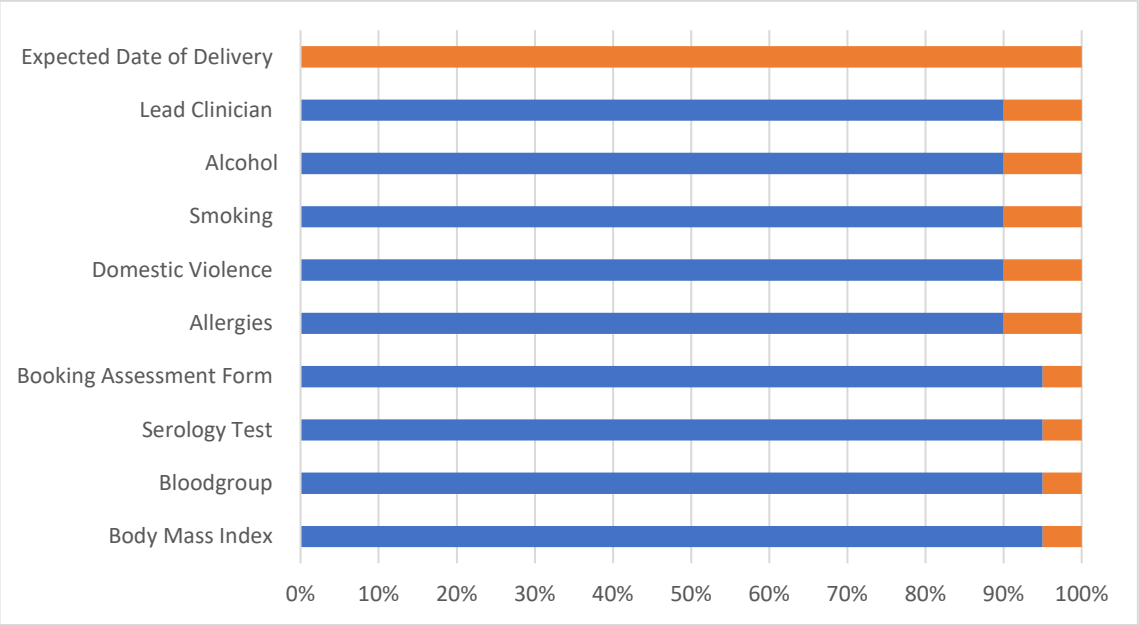


Figure 4.6: Audit results for booking visits report

4.5 Discussion

This study highlights the complexity of implementing an electronic health record for staff. The purpose of this paper is to show the many factors that are needed to be considered to ensure staff are engaging with the electronic chart. Staff engagement is key to the success of the EHR.

This study found that a primary concern for staff was that their colleagues found it difficult to utilise the EHR and the need to continue learning while using it. There is a need to improve communication among staff – to enhance access to lessons learned between staff. Most healthcare systems have challenges and even if the technological capabilities are there, a communication and support structure is required to make it work.[105] Teamwork during organisational change improves adoption of an EHR and this may affect how staff use and discuss the EHR.[113]

One issue that arose for staff in this study was the time required to login to the system to access records. This hospital was the first site to 'go live' and this was rectified as other hospitals came online. This is an example of an associated issue that can cause negativity and annoyance for staff and one that limits their engagement with the EHR thus delaying optimal adoption. This shows the importance of a site-by-site approach for implementation to rectify issues. The importance of ongoing evaluation with staff over and beyond the go live period does allow for the identification of problems that can be fixed through workflow changes or technical changes.

Respondents of this survey (42% n= 73) agreed that the training provided prepared them to perform their duties using the EHR. Some 68%, (n=111) of respondents in this survey were from the nursing/midwifery profession. Studies have examined how nurses have varying amounts of computer experience and that individuals may benefit from basic computer sessions as well as individualised training. [113] This unit did undertake a digital skills assessment and basic training in computers before any EHR training. It can be argued that globally we have moved forward technically so much in the last numbers of years that this issue should not affect implementation. However, there may still be a lack of skills and confidence within the profession, and they might benefit from additional engagement regarding how they wish to be trained (shorter sessions, focus on certain aspects of the chart, align to workflows, etc.) that may lead to a positive outcome. [114]

Our study showed that staff requested additional training to update their skills and to further maximise the use of the EHR. We found that 78% (n= 134) of respondents requested additional training. However, engagement and research

are required with staff regarding what training they require and how best to provide it. Additional training was provided at specific workflow-based areas and that can be seen in the results of the data audits. However, there is still the opportunity to improve data accuracy and completeness. Regular data quality audits are required to ensure data is completed effectively and efficiently. Daily and weekly examination of data reports can provide evidence of patterns of how and why staff are not completing the data. There are limitations for hospital management in providing training, as they may not be able to release staff to allow for further training. However, the cost of staff underperforming, and loss of productivity does affect the overall running of the organisation and may effect patient safety.[31]

Bauman *et al* comment in their systematic review that two studies examined the changes pre and post EHR system introduction. They found an increase in the proportion of time spent on documentation.[28] Studies have shown varying outcomes regarding time saved[115,116] and further investigations are needed regarding time saving; examining if time is saved through the EHR or if time is saved through a reduction in administration tasks. Another issue that could be affecting time saved may be due to an increase in the efficiency of workflows. Staff workflows play an important part in the introduction of an EHR and a well-planned workflow could affect the implementation by assisting staff.[117] Further research is required on evaluating workflow processes following the implementation of the electronic record.

Staff noted that patient safety and an improvement in patient care could be impacted by the introduction of the EHR. There is evidence to suggest that EHRs reduce medication errors, improve data and overall patient care. However, concerns are evident from respondents regarding technical issues, data entry errors and the impact of poor design.[48] The current literature reports a growing acceptance of EHRs, although there are concerns regarding the definitions and terminology used for data accuracy and completeness of records, interoperability with related systems, and the privacy and security of patient health data.[17,20]

As the staff become more familiar with the system and following further training they will grow in confidence when using the chart.

The staff in this study were aware of who to go to for support but also felt that the project team were technology savvy. The provision of support for staff is important for the implementation phase as it allows staff to feel secure and optimistic about the change. Further research is required to examine the impacts of a large systematic change on staff, on their roles and job satisfaction. There is a need for a greater understanding of what works and what improvements are needed.[118]

4.6 Conclusion

Staff are a crucial element in the implementation of any EHR system. They are critical to its success and can provide essential feedback as to what is working and what can be improved.[118] This project provided an opportunity to highlight the complexity of implementing an electronic health record for staff. It showed that to truly understand the adoption of an EHR, innovative techniques are required to show how staff rate the success of the implementation. Research[119] indicates that EHRs may improve documentation, thereby increasing the accuracy and completeness of patient data. The transition from paper-based to electronic records is expensive at the onset, requires substantial time and resources for implementation, training and evaluation and there is a lack of evidence on return of investment. This study provides evidence of how an EHR can be implemented with little disruption to staff outputs or patients. Many staff have returned to a high level of productivity and it now allows for further examination of the impact of the EHR on patient safety, improvement in documentation and training requirements.

Chapter 5:
Applying a National Data Quality Framework to a clinical audit: the National audit of Obstetric Haemorrhage in the Republic of Ireland 2011-2013

McKernan J, San Lazaro Campillo I, Manning E, Leitao S, Corcoran P, Greene R.

Submitted to the Clinical Audit Journal

Chapter 5: Applying a National Data Quality Framework on a clinical audit: the national audit of Obstetric Haemorrhage in the Republic of Ireland 2011-2013

5.1 Abstract

Background/Objective

Internationally Major Obstetric Haemorrhage (MOH) is increasing and the need to capture useable, quality data to improve clinical practice outcomes is imperative. The objective of this study was to examine the data quality from a baseline national audit of MOH to inform the data specifications for a follow-up national MOH audit. The aim of this study was to examine the completeness and accuracy of cleaned data collected in the MOH audit from 2011 to 2013. In addition, we planned to review the format of questions, assess the data responses, and update the data collection tool, based on the findings.

Methods

To carry out this process we undertook a four-step approach including incorporating elements of the Health Information and Quality Authority (HIQA) *Guidance on data quality framework for health and social care:* [68]

- Literature Review
- Data quality improvement cycle - the suggested audit process incorporating data quality assessment
- Examination of the data for valid, invalid, and missing data
- Applying a data quality assessment tool

The literature review was carried out to place our own research within the context of existing literature and justify the need for additional research. For the next stages of the process, we used the national guidance on a data quality framework for health and social care published in 2018 by the Health Information and Quality Authority (HIQA) in Ireland. After this process we assessed the data quality from the MOH audit dataset. The assessment was undertaken by examining individual variables in the data set. The data was divided into valid, invalid, and missing

data/completeness. Finally, we assessed the data quality using the five dimensions of quality included in the national guidance on a data quality framework. The five dimensions used are: (1) relevance, (2) accuracy and reliability, (3) timeliness and punctuality, (4) coherence and comparability, and (5) accessibility and clarity.

Results

We set out using the terminology of a data quality improvement cycle to ensure we maintained the continuous approach of improvement. The overall aim and specific objectives were set out first, followed by reviewing the current national clinical practice described in the prevention and management of primary postpartum haemorrhage against the research standards, to decide a set of key data points (KDPs) and to value the time and effort of re-auditing the audit. Following this process, we divided the data into valid, invalid, and missing data/completeness. The section with a higher number of missing data was clinical records and documentation (66.8%), followed by labour and delivery (24.5%), transfer (15.2%) and prophylaxis (21.1%). The remaining sections had at least an 80% of data completeness. The sections with a higher data completeness were resuscitation, fluid resuscitation (98.9%) and monitoring (98.3%). The dimension with the highest percentage for data quality was coherence, followed by accessibility.

Conclusion

Healthcare data for audit purpose and for secondary use of data in research is becoming more and more important. However, processes need to be implemented in audits to allow quality data to be produced. Following a framework and adapting it for the needs of an audit allows for a greater understanding of why and how data is being collected.

Keywords

Data Quality**,** National Data Quality Framework, Major Obstetric Haemorrhage, clinical audit data

5.2 Introduction

Data is defined as the "collection of elements on a given subject; it is the raw facts and figures expressed in various media that can be captured, manipulated, and communicated".[120] Data processed into meaningful form is called information, and this information is the raw material of quality improvement.[120] In general, data follow a lifecycle in which it can become information. The first stage of the lifecycle is the capture of the data, followed by the submission, processing and analysis of the data into information, which can be disseminated to knowledge users. However, information and knowledge are not meaningful if the quality of the data is not preserved in each of these stages.[68]

Ensuring data quality assurance and data management are key processes when carrying out collection of data for any type of research study or audit. The reliability of the research findings and ensuing recommendations will be affected by the quality of the data collected. However, very often these processes are neglected or overlooked.[115] Healthcare management, policy development and research are focusing more and more on the quality of data.[121]

In Ireland, the Health Information and Quality Authority (HIQA) is the independent authority established to drive high quality and safe care for people using health and social care services. According to HIQA, there is an urgent need to improve the structures in place to ensure data is not lost and that those responsible for planning services develop a coherent and integrated approach to improve the quality of health information.[68]

The National Perinatal Epidemiology Centre (NPEC) is an audit and research centre that collaborates with Irish maternity services to translate clinical audit data and epidemiological evidence into improved maternity care for families in Ireland. The centre collects audit data from all 19 maternity units on perinatal outcomes in Ireland. For example, from 2011 to 2013, the NPEC carried out a national audit on major obstetric haemorrhage (MOH). MOH is a leading cause of maternal morbidity and mortality worldwide.[116,117] In high income countries, MOH is one of the most common forms of severe maternal morbidity (SMM). In the Republic of Ireland, there was an 11% increase in incidence rate of MOH events from 2.34 per

1000 maternities in 2011 to 2.60 per 1000 maternities in 2013 [124]. The MOH rate continues to increase through the following years until the SMM report in 2019 (2.44 per 1000 maternities in 2014, 3.08 in 2016, 3.19 in 2018 and 3.31 per 1000 maternities in 2019). Over the nine years of the national audit there has been a 44% increase in the MOH rate.[124]

The collection of this longitudinal, observational data from the maternity units allows for greater statistical power and external validity of the outcome measured.[125] The analysis and dissemination of this data allows the foundations for quality improvement initiatives, research activities, policy decisions, and public reporting.[120] The collection of quality data is a key strategic aim of the centre. Therefore, it is imperative that high standards of data completeness and accuracy are maintained through the audit cycle. The audit cycle is a "clinically led, quality improvement process that seeks to improve patient care and outcomes through the review of care against explicit criteria. Where standards are not met, changes are implemented, and re-auditing is used to confirm improvement in patient care".[126,127]

5.3 Objectives

The overall objective of this study was to examine the data quality from a baseline national audit of MOH to inform the data specifications for a follow-up national MOH audit.

The aim of this study was to examine the completeness and accuracy of cleaned data collected in the MOH audit from 2011 to 2013. In addition, we planned to review the format of questions, assess the data responses, and update the data collection tool, based on the findings.

5.4 Methods

Study design and study population

To carry out this process we undertook a four-step approach including incorporating elements of the Health Information and Quality Authority (HIQA) *Guidance on data quality framework for health and social care*

- Literature review
- Data quality improvement cycle - the suggested audit process incorporating data quality assessment
- Examination of the data for valid, invalid, and missing data
- Applying a data quality assessment tool

The literature review was carried out to place our own research within the context of existing literature and justify the need of additional research in this context. The criteria for considering studies for this review were data quality papers which assess the data quality of clinical audits on MOH. Two authors independently (JMK and ISC) searched the following the peer-reviewed electronic bibliographic databases: PubMed, CINAHL Plus, and Web of Science (Web of Knowledge). We did not search the grey literature databases. Medical subject headings (MeSH) or major topics were used when these were available, and they were adapted to each requirement of the electronic databases. The search strategy included terms relating to the topics: “data quality”; “data framework”; “Data quality review”; “clinical audit”; “Major Obstetric Haemorrhage”. MeSH terms used were “data quality”; “clinical audit” and “Major Obstetric Haemorrhage”.

There were no restrictions by study design, year, or language. The references list of the relevant studies and reviews were identified through the search. A total of 87 citations were identified through database searches. Supplementary file 1 shows the total hits for each term for each electronic bibliographic database. Search results were screened by two reviewers (JMK and ISC), first by titles and then by abstracts. This literature review found several clinical audits on MOH; however, none of the reviewed studies assessed the quality of the data in those clinical audits, and therefore, none met the full inclusion criteria for this review.[128–130]

For the next stages of the process, we used elements of the national guidance on a data quality framework for health and social care published in 2018 by the Health Information and Quality Authority (HIQA) in Ireland. One element of this document is a data quality assessment tool, based on the Canadian Institute for Health Information (CIHI’s), the Information Quality Framework (IQF) and the

Generic Statistical Business Process Model (GSBPM).[68] We set out a suggested audit process using the terminology of a data quality improvement cycle[68] to ensure we maintained the continuous approach of improvement. See figure 5.1 below.

After this process we assessed the data quality from the MOH audit dataset. The assessment was undertaken by examining individual variables in the data set. The data was divided into valid, invalid, and missing data/completeness. Invalid data has an impact on the use of a dataset.[68] The assessment of completeness and accuracy was done by calculating the percentages of valid, invalid and missing data for each variable included in the MOH audit dataset. A valid value was defined as "number of cases that have a correct value for a specific observation", an invalid value was defined as "number of cases that have an incorrect value for a specific observation" and a missing value was defined as "a value that indicates that no data value is stored for the variable in the current observation". A total of 14 sections were identified in the MOH audit dataset. The averaged percentages of valid, invalid, and missing values were reported for each of the 14 sections to compare the level of completeness within sections.

The MOH audit dataset related to all MOH cases reported to the National Perinatal Epidemiology Centre (NPEC) from all the maternity units that agreed to participate in the audit in the Republic of Ireland (ROI) from January 2011 to December 2013 (19 of 20 total maternity units).[124] A MOH case was defined as a woman who had an estimated blood loss of at least 2,500 ml, and/or had transfusion of five or more units of blood and/or had documented treatment for coagulopathy.[124] The full description of the methodology of the MOH audit is explained in the annual report for the Severe Maternal Morbidity (SMM) audit in Ireland, 2011 and 2013.[124 131]

Each of the 19 maternity units had a coordinator/s who completed the MOH audit form and submitted data to the NPEC. The NPEC project manager reviewed all data with the unit co-ordinator and carried out the data cleaning. The data was analysed, and a report was written. The last stage was the dissemination of unit specific reports to all maternity units and the national report to various stakeholders including the Department of Health.

Finally, we assessed the data quality using the five dimensions of quality included in the National guidance on a data quality framework. The five dimensions used are: (1) relevance, (2) accuracy and reliability, (3) timeliness and punctuality, (4) coherence and comparability, and (5) accessibility and clarity. Each dimension of the data quality assessment tool is divided into characteristic, criteria, details, and assessment. A score from one to three was arbitrarily chosen and applied to each of the possible assessments (not completed, partially completed or fully completed, respectively) for each of the questions in each sections of this assessment tool.[68] We applied an arbitrary scoring system using (no=1, partially=2 and yes=3) to the assessment element. This score system was applied to obtain a numeric value of the data quality of the MOH audit. A higher score represents higher data quality for the dimension. The total score for each dimension was calculated and then it was divided by the maximum total score/maximum data quality of each dimension. These scores were turned into percentages for each dimension. We used this scoring system so that we could monitor the improvement over time.

The launch of the MOH audit planned for January 2020 was postponed to January 2021 due to the SARS-COVID-19 pandemic. This moves the monitoring and review of the implemented improvements to the data quality audit to the end of the year of 2021.

Ethical approval

The data in the National MOH audit are anonymised; and while ethical approval is not required; NPEC has ethical approval for the work undertaken in all audits.

5.5 Results

Following the national guidance on data quality framework for health and social care we devised the stages and the tasks (Figure 5.1) that we envisaged would be useful in the planning phase of the development of the audit tool to ensure we factored in data quality. We set out using the approach of a data quality improvement cycle[68] to ensure we maintained the continuous approach of improvement. The overall aim and specific objectives were set out first, followed by reviewing the current national clinical practice described in the prevention and

management of primary postpartum haemorrhage[132] against the research standards, to decide a set of key data points (KDPs) and to value the time and effort of re-auditing the audit. We set out how we envisaged liaising with hospital co-ordinators to achieve the continued improvement of data quality. We factored in how we would disseminate results from the audit as well as from the continued data quality improvement cycle.



Figure 5.1: The suggested audit process incorporating data quality assessment

A total of 497 cases with MOH were reported from January 2011 to December 2013 in the ROI. Demographic characteristics and main findings from the MOH audit were reported elsewhere.[124] A total of 144 variables were reviewed to assess the completeness of the full dataset of the MOH audit. Figure 5.2 shows the percentage of data completeness by section. The section with a higher number of missing data was clinical records and documentation (66.8%), followed by labour and delivery (24.5%), transfer (15.2%) and prophylaxis (21.1%). The remaining sections had at least an 80% of data completeness. The sections with a higher data completeness were resuscitation, fluid resuscitation (98.9%) and monitoring (98.3%).

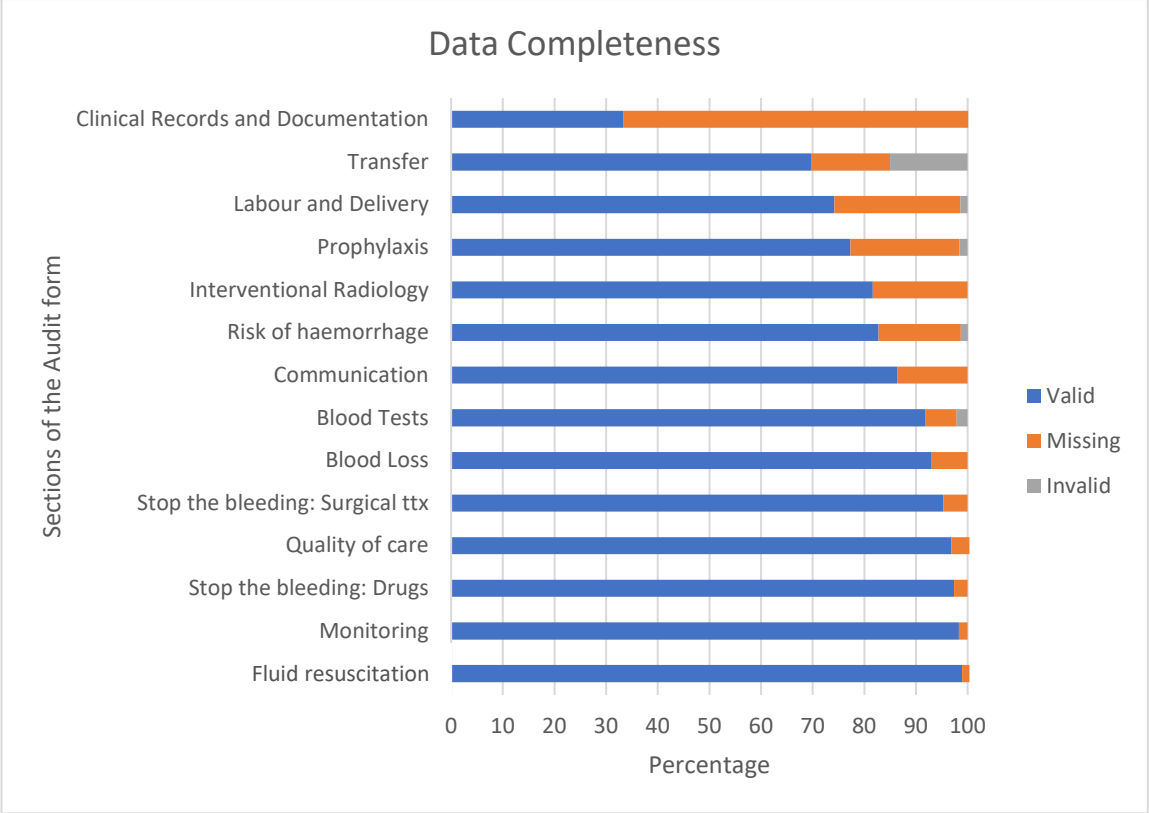


Figure 5.2: Data completeness of all the sections in the MOH dataset

For this audit we use the term valid, for data that was completed and verified at the cleaning process. This was data that could be used in the analysis stage of the process. The sections that showed invalid data were transfers, blood tests, prophylaxis, labour and delivery and risk of haemorrhage.

- An example of an invalid data was writing not applicable when the patient was not admitted to ICU and the form asked if the woman was admitted to general high dependence unit or in a high dependency room on labour ward.
- Also submitting "0" or "1" when asked "How much blood was cross-matched once MOH recognised?"
- Another example is writing an indication for caesarean section or identifying the grade of obstetrician performing a caesarean section when caesarean section was not performed, and another mode of delivery was selected previously (vaginal or assisted delivery).

Figure 5.3 shows the percentage of missing data for the section "clinical records and documentation". This is an example of sections with the highest percentage

of missing data in this audit. These questions were free text questions that were inadequately completed in the audit form. These questions were left blank on the form. Factors that may have influenced this could be time, length of question and staff completing the form may have perceived there was a requirement of writing long detailed notes.

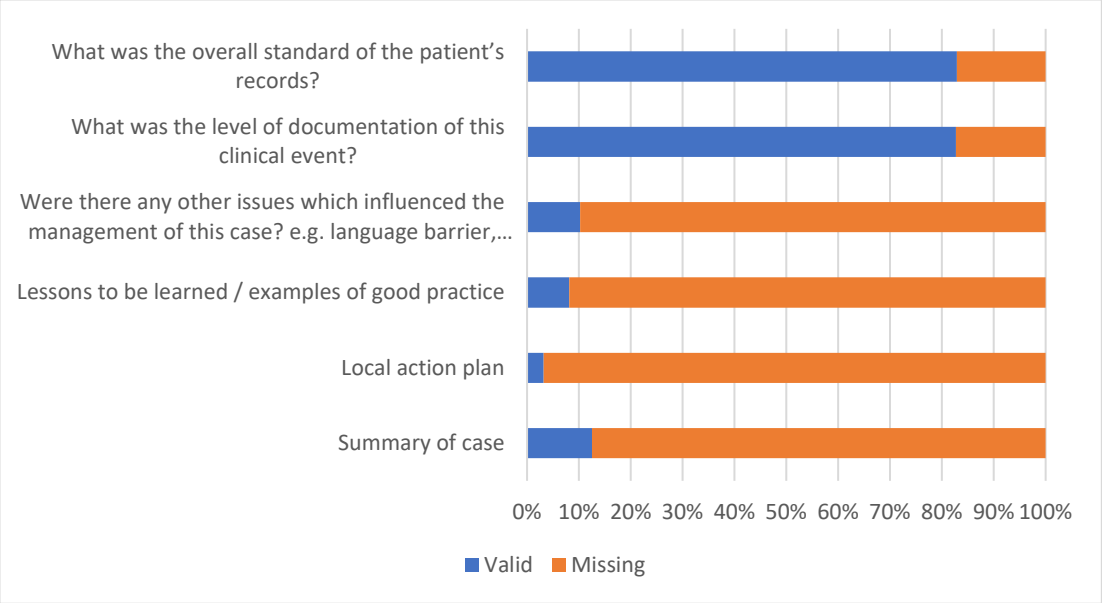


Figure 5.3: Data completeness for the section "clinical records and documentation" in the MOH dataset

The total scores for each dimension can be seen in Appendix VI. Figure 5.4 shows the total percentage of the data quality tool for each dimension in the MOH audit. The dimension with the highest percentage for the data quality was coherence, followed by accessibility. The accuracy and reliability dimension includes the key component of completeness for accuracy.

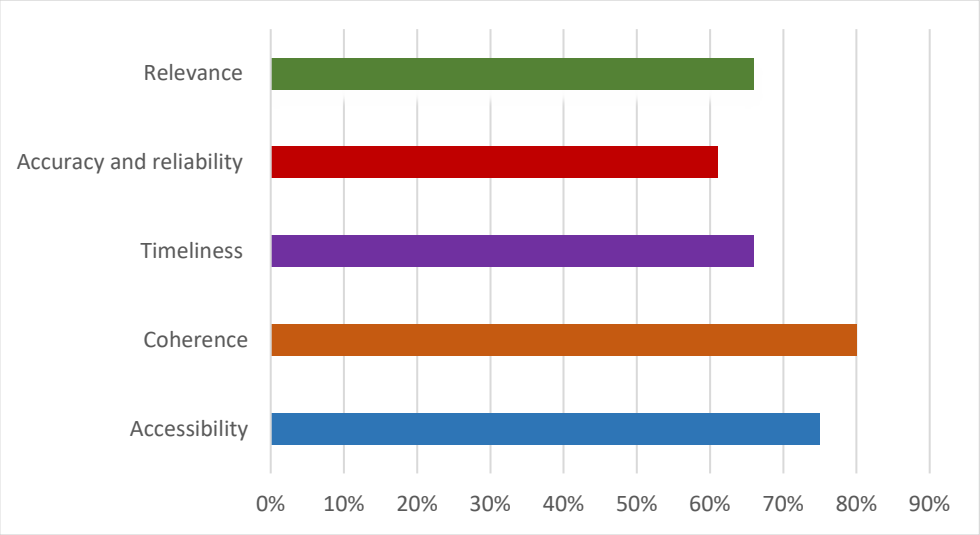


Figure 5.4: Data quality of the five dimensions for the Major Obstetric Haemorrhage (MOH) dataset

Following the 4 step process and discussion with the SMM expert group it was decided to move from the original paper-based collection tool to an online data collection and submission process. The original paper-based form was configured into a web-based system for electronic Case Report Forms (eCRFs) - Castor EDC[133] which allows for safe and valid data collection. In this stage, the audit coordinators were identified and trained in the new online database Castor EDC. Several webinars and workshops were planned, organised and carried out to accomplish this phase. The coordinators' feedback was taken into consideration when building and validating the revised MOH audit tool.

5.6 Discussion

This audit describes the process applied to assess the data quality of a national clinical audit about Major Obstetric Haemorrhage (MOH) events in the Republic of Ireland from 2011 to 2013. Coherence and accessibility were the data quality dimensions which scored higher in this audit. Accuracy and reliability scored the lowest in this study. After assessing data completeness of the 14 sections of the MOH form, this data quality audit found that clinical records and documentation was the section with the higher number of missing data, followed by labour and delivery. The remaining sections of the form had at least 80% of data completeness. Transfers, blood tests, prophylaxis and labour and delivery had the higher invalid data (higher percentage 15% to lower percentage 2.1%) The quality review has led to significant consideration of every question in the audit, answer options and the building in of approaches that enhance data quality and reduce the inaccuracy noted in the previous MOH audit. Assessing the relevance of questions, etc. has allowed for streamlining of the audit tool and moving online has added procedures to assist the data inputters. This has been a very valuable exercise for our MOH audit. We believe this to be the first of its kind in data quality assessment – checking validity, completeness and assessing the data against a data quality framework.

5.6.1 Comparison with other studies

To our knowledge, no previous data quality audits have been published in peer review literature that outlines the full process of assessing the quality of the data of a national clinical audit on MOH. The scant amount of evidence in this field have

limited the comparison of our findings with other studies. However, other studies in different fields have shown the importance of evaluating data quality. For example, David *et al* (1980) presented the results of a data completeness and accuracy of birthweight and gestational age data in computerised birth files in the State of North Carolina.[134] One data quality audit assessed the influence of data quality assessments on data availability and completeness in a voluntary medical male circumcision programme in Zimbabwe.[135] This audit evaluated these two parameters before and after a data quality audit and found that client intake forms improved after the data quality audit.[135] Another study examined completeness and data validation of clinical diagnoses of basal cell carcinoma and squamous cell carcinoma in the United Kingdom.[136]

5.6.2 Strengths and limitations

One of the main strengths of this study is that a national data quality framework was applied to evaluate and assess the quality of the data for the national clinical audit in the Republic of Ireland. In addition, the national data quality framework is based on well-recognised and international data quality frameworks.[68] However, this study is not exempt of limitations. One limitation may be that we could extend the search strategy to include the grey literature. We decided to focus on peer reviewed publications for this project. For example, the dataset, which was used for the data quality analysis, had already been processed for data cleaning and data verification. Therefore, our findings might have shown a better quality of the completeness and data verification steps than the raw dataset. Secondly, the scope of this study was focused on assessing the data quality of the MOH dataset. Therefore, this study did not present results on data validation of MOH cases. This was the first time that a clinical audit about MOH was carried out in Ireland. This might imply that data entry staff might have more questions about the data form, the sources to find the specific information and the time spend in completing the 18 pages of the MOH form.

5.6.3 Implications

A lesson learned from this process was moving the audit form online. The online system allows data validation checks to be incorporated into the audit form. One such check is the ability to limit free text answers. In essence you are ensuring the

person completing the form is deciding on data. An online system can provide a dashboard of missing variables for the audit co-ordinator to explain why the data is missing. Invalid data is no longer an issue as the online system does not allow for this type of human error. Asking the right questions provides the correct data; however, asking the question to ensure the data is maximised, it is an important element of audit. From the results of this audit, we can see the importance of a well thought out data quality process to provide valuable useable data.

The process of using the HIQA Data Quality framework for health and social care provided several insights. The HIQA framework is an international researched piece of work that consolidates the theories of similar frameworks and provides a useable framework to maintain data quality standards.[68] The adaptation of the assessment tool provided the structure for a marking system to be developed. It allowed for a structure to be in place that can be used again as the next MOH audit progresses. Each dimension can be analysed and improved as the audit cycle progresses. Data quality audits provide a structure to continually assess the audit whatever the topic. It is important to continue with a structure to ensure feedback is provided to units to improve data capture and data documentation. The completion of national audits may be time consuming however regular discussion with audit coordinators can allow for improvement in documentation at source which in turn saves time for the completion of the audit form.

5.7 Conclusion

Internationally MOH is increasing[122,123,131] and the need to capture useable, quality data to improve clinical practice outcomes is imperative. Healthcare data for audit purpose and for secondary use of data in research is becoming more and more important.[137] However, processes need to be implemented in audits to allow quality data to be produced. Following a framework and adapting it for the needs of an audit allows for a greater understanding of why and how data is being collected. It also allows for improved effectiveness of audit in clinical practice.[138] Audit tools should be regularly assessed against a data quality framework/tool to ensure they are appropriate for the assessment being undertaken.

Chapter 6: Investigating Data Quality in an Electronic Health Record

McKernan J, Corcoran P, Greene R.

Submitted to the Health Information Management Journal

Chapter 6: Investigating Data Quality in an Electronic Health Record

6.1 Abstract

Background/Objectives

The introduction of an EHR into the healthcare system allows an opportunity to collect defined structured and coded data that is easier to transform into information. While data quality is a problem in all domains, the digitisation process enhances the opportunity for monitoring data quality and offers the potential for better use of the data and the development of information for use in the service. For this research project we approached the issue differently, we aimed to look at data quality and investigate how it could be improved by taking a practical step by step process. We decided to take the time to really understand the data points and the format as inputted and produced in reports from our EHR.

Methods

This study took an approach that combines two phases to examine the data quality from an electronic patient record. It allowed the researchers to engage with the data quality process and examine how best this approach would work in the maternity setting. Initially we examined the data from year 1 -2018; once extracted from the system, we identified data quality issues. We then enacted an intervention and assessed the effect of a new data quality process. The process change was to introduce a data quality resource to assess the datapoints within 1-2 days after documentation of the care by the healthcare professional. Clinical data was extracted from the MN-CMS national database and descriptive analysis was performed. The aim of this phase was to check missing data and its significance. There are several agreed output reports developed at a national level.

Results

Following the exploration over the three years the following was found in the daily delivery report for the year 2018 the missing data ranges from 8% to 9%. The breastfeeding report has missing data of 7% to 10%. The Neonatal discharge report has missing data from 8% to 10% and the pregnancy loss report has missing data 5% to 10%. In the daily delivery report for the year 2019 the missing data

ranges from 7% to 9%. The breastfeeding report has missing data of 8%. The Neonatal discharge report has missing data from 8% to 10% and the pregnancy loss report has missing data 8% to 11%. In the daily delivery report for 2020 the missing data ranges from 7% to 9%. The breastfeeding report has missing data of 8% to 10%. The Neonatal discharge report has missing data from 7% to 10% and the pregnancy loss report has missing data 7% to 12%.

Conclusion

This practical step by step approach has shown that various steps are required to improve data quality. It isn't just one element, but several factors are required. Improvement in data quality is achievable if these factors are investigated and examined. All those who work in healthcare have a role to play in data quality. We have a responsibility to collect and capture data to ensure we provide the best care and allow the best assessment of the care we provide; in doing so we are being respectful to the patient.

Keywords

EHR, data quality frameworks, data points, missing data, definitions, step by step approach

6.2 Introduction

There is a growing focus on clinical data in recent years.[139] Healthcare systems are increasingly using outcome data to develop and improve patient centred care.[120] Data is collected and used to investigate the health of the individual, to assist the care of the individual, to run clinics, services/ hospitals, and hospital systems. This data is also used for audit, service evaluation and for research purposes. To use this data for health care, management, and quality improvement, we need to organize and transform it into information, making it easier to measure, visualize and analyse for the specific purpose.

The introduction of an EHR into the healthcare system allows an opportunity to collect defined structured and coded data that is easier to transform into information. While data quality is a problem in all domains, the digitisation process enhances the opportunity for monitoring data quality and offers the potential for better use of the data and the development of information for use in the service. EHRs may have data quality issues; there is evidence that incomplete patient records exist, and the subsequent record may not be used for the planned and necessary purposes. Studies have shown that there is not always a logical reason why data is missing or why some data is missing. There is a need to address these issues using different methods.[58]

The process of checking data quality can be tedious and time consuming and many healthcare workers do not see the value of this work and it is not a priority. There is an ethical and legal responsibility to ensure adequate direct data is available to ensure appropriate and safe care for individuals and to allow a robust assessment of the healthcare provided. Staff need to be aware of the importance of complete data, the organization must engender a culture around the importance of good data building blocks. To ensure accurate quality data is achieved at data entry level there is a requirement to provide appropriate tools, dataset requirements and training.

There are data modelling techniques, predictive modelling of data, missing data software that are all useful; the area is growing all the time in research and in industry. However, to fulfil the above requirements and responsibilities, we need

to have good complete datasets because there is a patient at the centre of care. As we move towards patient portals, allowing individuals access to their health information and making them a true partner in decision making about their care, we must ensure their records are accurate and complete; this requires a commitment to quality data. People expect (and should expect) this and believe this is already happening within the healthcare setting.[140,141]

For this research project we approached the issue differently, we aimed to look at data quality and investigate how it could be improved by taking a practical step by step process. We decided to take the time to really understand the data points and the format as inputted and produced in reports from our EHR.

Following an iterative, clinically led stakeholder engagement process across maternity services the EHR in Ireland for maternity and gynaecology patients was launched: *"The Maternal and Newborn Clinical Management System (MN-CMS) Project is the design and implementation of an electronic health record (EHR) for all women and babies being cared for in maternity, newborn and gynaecology services in Ireland. This record enables all maternal, newborn and gynaecology information to be shared with relevant providers of care as required in compliance with General Data Protection Regulation (GDPR)".* [142]

"The key benefits include:

- *Improved patient care as a result as of better communication, supported decision making and effective planning of care.*
- *More effective and efficient recording of information reflecting best standards in documentation.*
- *Enhanced clinical audit and research locally as a result of better-quality data.*
- *Informed business intelligence that will drive local and national management decisions.*
- *MN-CMS has a full audit trail capability to support security and detection of any data breaches."*[142]

MN-CMS allows for improved collection of routine data for clinical and organisational use. MN-CMS reduces the need for patient to reiterate information that they have already provided. In essence there is only a need to collect the data once and then for that data to be used for several data requests for example national audit, local audit, national statistics, and research. It has the potential to design the most cost-effective models of care and establish a national epidemiological database.[143]

The development of the EHR in Ireland allows for individual level data to be collected for every woman and baby using the service. The introduction of the system is a complete change management project and there is a requirement to evaluate the stages as the project progresses as this will enhance the overall value of the EHR. The aim of this project is to investigate the quality of data within the MN-CMS (EHR) for patients attending a tertiary unit in Ireland with 8000 births per year. The activity level for the unit is over 50,000 encounters per year.

6.3 Methods

Different methods have been proposed to investigate data quality.[68] This study took an approach that combines two phases to examine the data quality from an electronic patient record. It allowed the researchers to engage with the data quality process and examine how best this approach would work in the maternity setting.

Initially we examined the data from year 1 -2018; once extracted from the system, we identified data quality issues. We then enacted an intervention and assessed the effect of a new data quality process. The process change was to introduce a data quality resource to assess the datapoints within 1-2 days after documentation of the care by the healthcare professional.

The research is divided into two phases:

For this project, we used the Health Information and Quality Authority (HIQA) data assessment tool from the Guidance on a data quality framework for health and social care to assess the dimensions of data quality. We examined the five dimensions and assessed what it meant for MN-CMS. HIQA in Ireland is an independent authority established to drive high quality and safe care for people

using our health and social care services.[68] HIQA commented that in Ireland there is a need to develop a standardised approach to data quality. Poor documentation and poor data can lead to a variety of outcomes.[68] We recognised that the use of this framework ensures we are working within an agreed definition. There are frameworks in the literature that use different definitions.[144, 145,146] It is useful and important to use a standardised approach. We assessed the data quality using the five dimensions of quality included in the national guidance on a data quality framework. The five dimensions used are: (1) relevance, (2) accuracy and reliability, (3) timeliness and punctuality, (4) coherence and comparability, and (5) accessibility and clarity. Each dimension of the data quality assessment tool is divided into characteristic, criteria, details, and assessment. A score from one to three was arbitrarily chosen and applied to each of the possible assessments (not completed, partially completed or fully completed, respectively) for each of the questions in each sections of this assessment tool.[68] We applied the scoring system using (no=1, partially=2 and yes=3) to the assessment element. A higher score represents higher data quality for the dimension. The total score for each dimension was calculated and then it was divided by the maximum total score/maximum data quality of each dimension. These scores were turned into percentages for each dimension.

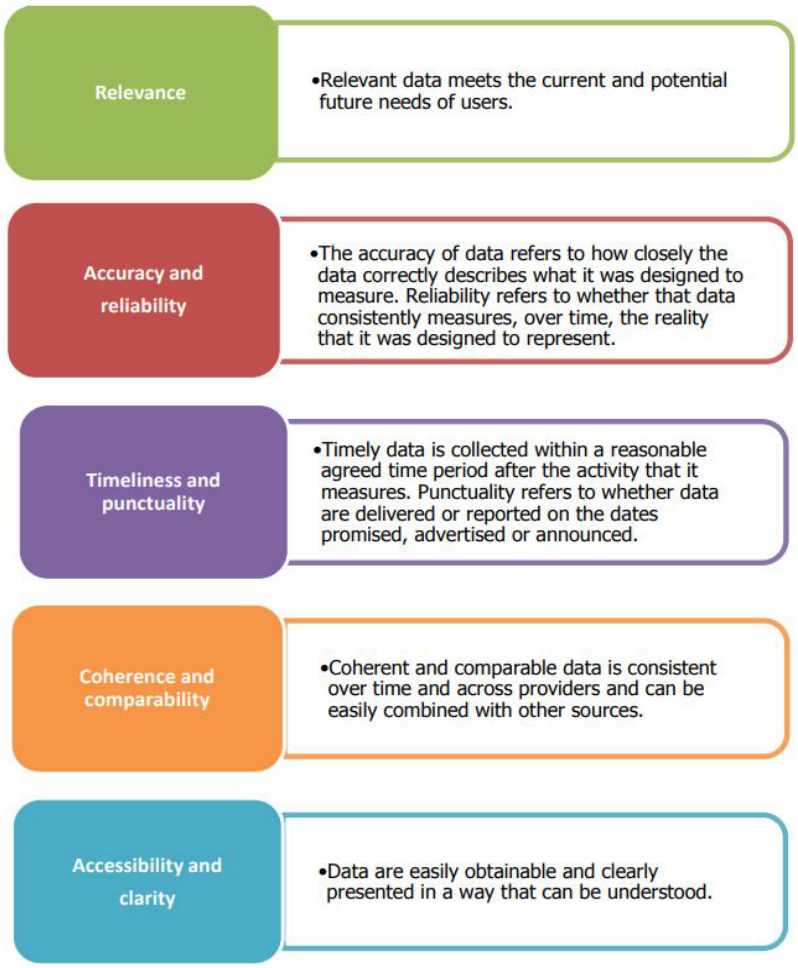


Figure 6.1: The dimensions of Data Quality as defined by Health Information and Quality Authority [68]

Phase 1:

We extracted clinical data from the MN-CMS national database. The aim of this phase was to check missing data and its significance. There are several agreed output reports developed at a national level (currently about 30 reports) – these are used in the maternity services (live on MN-CMS) in the day-to-day management. They are also an important data source for clinical practice, audit, and service evaluation. For this project, we used five of these reports to check and validate the data for one large maternity service. The reports are outlined in Table 6.1. The five reports chosen include the variables most frequently used for providing outcome data for the unit. These reports provide a picture of care for patients from their antenatal booking visit right through to discharge from the hospital after the birth of the baby.

The clinical data was exported from the system using Business Objects software and imported into Excel. We analysed each variable looking at its purpose. The purpose of this check is to determine if the variables were applicable to all women for example indication for caesarean section should only be completed for caesarean sections. We used Excel to ensure that elements of the project could be easily replicated without having to purchase specific software. We removed variables that would not be captured for all patients (e.g., urgency classification for patients who had a Caesarean Section). This was completed for the years 2018/2019/2020. We examined each month individually. This allowed a monthly breakdown of missing data for each of the reports.

The booking report was also chosen for examination; the booking report is data collected on all patients who have a booking visit when they first come to the hospital for care in the index pregnancy. This report has 89 variables collected and because many of the variables used in the report are not pertinent to all women, data completeness is not easy to assess. For example, all patients are asked about smoking with a yes/no answer, other questions would be posed if the answer is 'yes' but not if the answer is no'. However, it was a report that allowed for the development of better data and metrics.

Table 6.1: The reports reviewed, and the variables examined

Daily Delivery Report Labour and Delivery Ward Report	The daily delivery report is a data set that is comprised of outcome data following delivery for mother and baby. The data set includes variables that are not relevant to all cases (e.g., membrane status). The majority of these were removed from the dataset to allow the completion of the set to be checked. However, some were included to show the steps required to prepare a data set for secondary use.
Variables Analysed	Medical Record Number /Financial Number/Person Name- Full/Parity Before Delivery/Payer Type/Admit Source (Mother)/Previous caesarean section /Delivery Date, Time (Mother)/Birth Order (Mother)/Neonate Outcome (Mother)/Pathway to Delivery (Mother)/Birth Weight (g) – Mother/Estimated Gestational Age (Mother)/Mother (Delivery Category)/Delivery Type All (Mother)/Membrane Status (Mother)/Artificial Rupture

	Indication (Mother)/Oxytocin (Mother)/Delivered By (Mother)/Clinician (Midwife) Mother/Clinician (Obstetrician) Mother/Baby Transferred To: (Mother)
Breastfeeding Report	This report includes data about every baby discharged from the hospital and details the feeding method(s).
Variables Analysed	Baby Medical Record Number /Financial Number/Baby Name/Discharge Location/Discharge to Location/Neonate Outcome/Delivery Type – All/Discharge Month (Infant) Birth Month (Infant)/Birth Date (Infant)/Discharge Date (Infant) Birth Weight (g) – Infant/Gestational Age (Infant)/Transfer To/Skin to Skin Contact/Initial Feeding Type at Delivery/Initial Feed Type Newborn/Last Feed Type Newborn/Initial Feeding Method Newborn/Discharge Feeding Method Newborn/Feeding Type at Discharge/Feeding Type at Discharge Derived – Final/Measured Weight
Neonatal Discharge Report	This report included information on all babies discharged from the neonatal unit in the hospital. Six variables were removed from this report because they are not relevant to all cases.
Variables Analysed	Baby Medical Record Number /Financial Number/Payer Type/Forename/Surname/Date of Birth/Sex/Mother Ethnic Group/Newborn Blood Spot Due/Encounter Admission Date/Admission Date to Neonatal Unit/Reason for Admission/Source of Admission/Encounter Discharge Date Time/Discharge Date from Neonatal Unit /Discharge Time from Neonatal Unit /LOS Neonatal Unit /LOS Admit to Discharge (Days)/Professional Skilled Services/Infant Feeding on Discharge/Babies Last Location/Delivery Method description/Gestational Age/Admission Temperature/Birth Weight (g)/Last Weight Measured (g)/Last Length Measured/Newborn Birth Length/Birth Head Circumference/Last Head Circumference/Apgar Score 1 Min/Apgar Score 5 Min/1st Discharge Diagnosis/2nd Discharge Diagnosis/Discharged To/Discharged By/ neonatal intensive care unit Acuity
Pregnancy loss Report	This report has information on cases in relation to pregnancy loss including first trimester and second

	trimester loses. Three variables were removed from this report as they were not relevant to all cases.
Variables Analysed	Medical Record Number /Mother Name/Financial Number/Max Pregnancy Identifier/Pregnancy Loss Date & Time/Pregnancy Loss/Max Pregnancy Start Date/Max Pregnancy End/Max Date of Delivery/Max Delivery Outcome/Max Method of Delivery/Estimated gestational age Date/Estimated Gestational Age/Previous Births (Pre Millennium)/Previous caesarean section Ind

Phase 2:

In 2019 there were changes to the data quality process with the introduction of a data quality manager (DQM). The DQM undertook quality checks on the complete daily delivery list (labour and Delivery Ward Report). The data errors identified included missing datapoints, inaccurate data points e.g., completing the incorrect mode of delivery or e.g., documenting a data item in the incorrect area of the patient record, or e.g., a structured datapoint inappropriately placed in a didactic clinical note. The DQM kept an excel file of the number of corrections undertaken per month. To enhance the data quality these errors were corrected in the patient record, which provided for more accurate data for patient care and more complete reports.

Ethical approval was granted by the Cork Research Ethics Committee (CREC) (ECM 4 (i) 04/12/18) and the project was reviewed by the Hospital Local Information Governance Committee, prior to commencement.

6.4 Results

Figure 6.2 below outlines the dimensions of data quality as defined by HIQA in relation to MN-CMS. This framework provided a robust and standardized tool to assess data quality. We defined how each dimension is used in relation to the EHR. The percentage noted was calculated after the completion of the data quality assessment tool. [68] Further information is available in Appendix VIII.

Relevance – 83%

This work identified variables that require completion in all cases and variables that are not expected for every patient. Better understanding of data for analysis requires completion in all cases.

Accuracy and reliability – 76%

There are checks built into the system to ensure the accuracy of data. For primary data there are systems in place to address missing data as defined variables have been decided and are checked regularly.

Timeliness and punctuality – 91%

Timeliness is not an issue for EHR – documentation time is close to care provision. Validation checks need to be carried out close to the point of documentation to ensure timely reporting.

Coherence and comparability -85%

Data is consistent, the EHR is a single source of truth ensuring that data should only be entered once to avoid errors. There is ongoing work to ensure that the data remains easily combined with other sources. This understanding is vital for data analysis and information generation. The data in its simplest form e.g., gestation is calculated for weeks plus days and can easily be recalculated to a different definition.

Accessibility and clarity – 83%

Once the data is extracted from the system the data needs to go through some further checks. However, in comparison to paper formats the data is very easily assessed and audited.

Figure 6.2: MN-CMS data as per the HIQA data quality framework

Phase 1:

Following the extraction of the data from the system we can see from the figures below the percentage of missing data in each year from each report per month. The circular presentation of the data allows the missing data to be examined monthly. It allows one to see what areas need particular attention and areas that are completed well. Missing data was calculated for each data point. If a data point was missing for one woman in a month it counted as missing data point for that report. In a hospital setting there are a number of staff changes throughout the year (Junior doctors change en masse – January and July) and examining the data on a monthly basis allows a structured approach which can identify particular problems at times of change as above.

In the daily delivery report for the year 2018 the missing data ranges from 8% to 9%. The breastfeeding report has missing data of 7% to 10%. The Neonatal discharge report has missing data from 8% to 10% and the pregnancy loss report has missing data 5% to 10%.

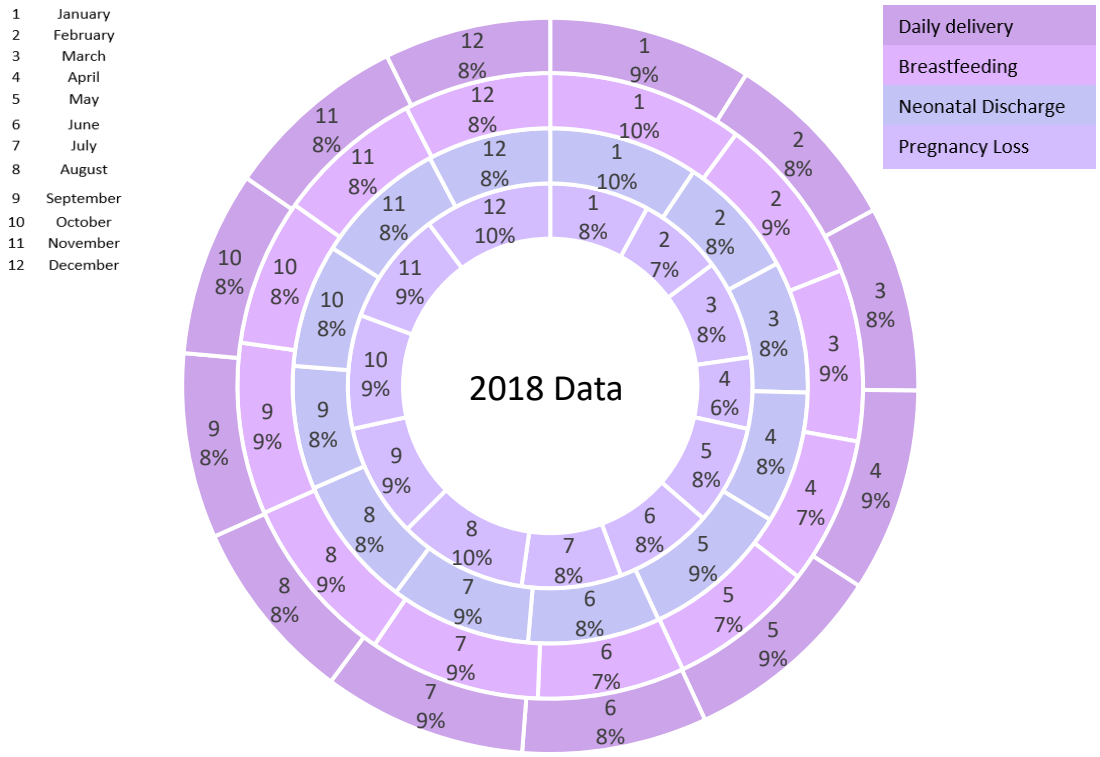


Figure 6.3: Percentage of missing data from 2018 for the report; daily delivery, breastfeeding, neonatal discharge and pregnancy loss. Within the boxes the first number is the month as per the legend and the second number is the percentage of missing data points

In the daily delivery report for the year 2019 the missing data ranges from 7% to 9%. The breastfeeding report has missing data of 8%. The Neonatal discharge report has missing data from 8% to 10% and the pregnancy loss report has missing data 8% to 11%.

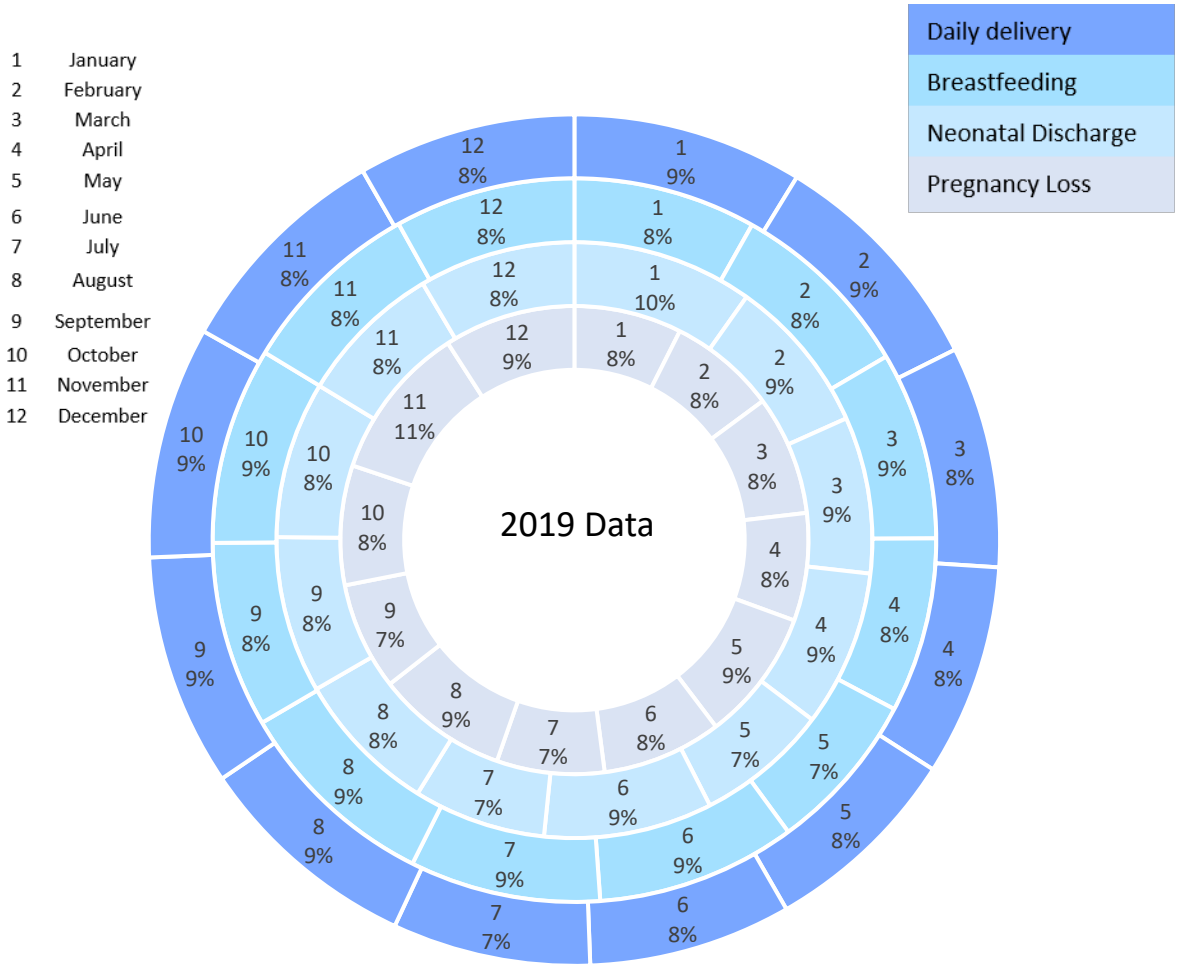


Figure 6.4: Percentage of missing data from 2019 for the reports daily delivery, breastfeeding report, neonatal discharge, and pregnancy loss report. Within the boxes the first number is the month as per the legend and the second number is the percentage of missing data points.

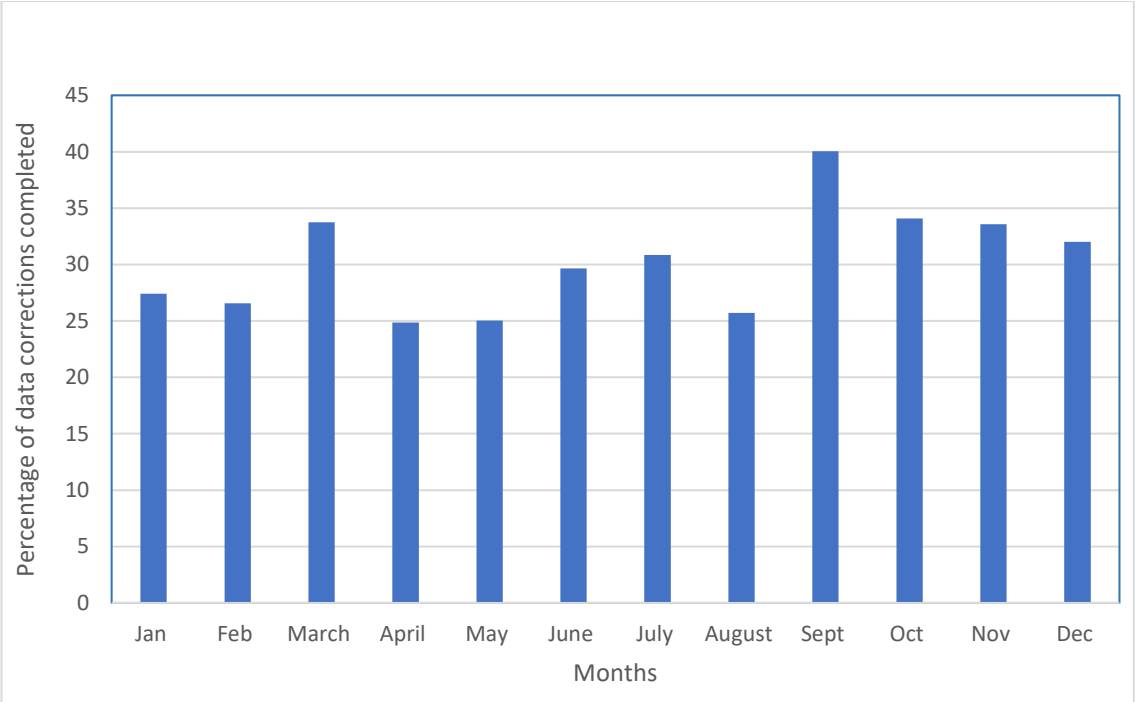


Figure 6.5: Percentage of corrections carried out by the Data Quality Manager on the Daily Delivery Report

We examined the corrections completed by the DQM for the year 2019. Corrected data was calculated for each data point. If a data point was corrected for one woman in a month it counted as a corrected data point. We can see from the graph above for the daily delivery list that the highest number of corrections of 40% was completed in September. September would be noted as a busy month in the hospital and may contribute to missing data.

In the daily delivery report for 2020 the missing data ranges from 7% to 9%. The breastfeeding report has missing data of 8% to 10%. The Neonatal discharge report has missing data from 7% to 10% and the pregnancy loss report has missing data 7% to 12%.

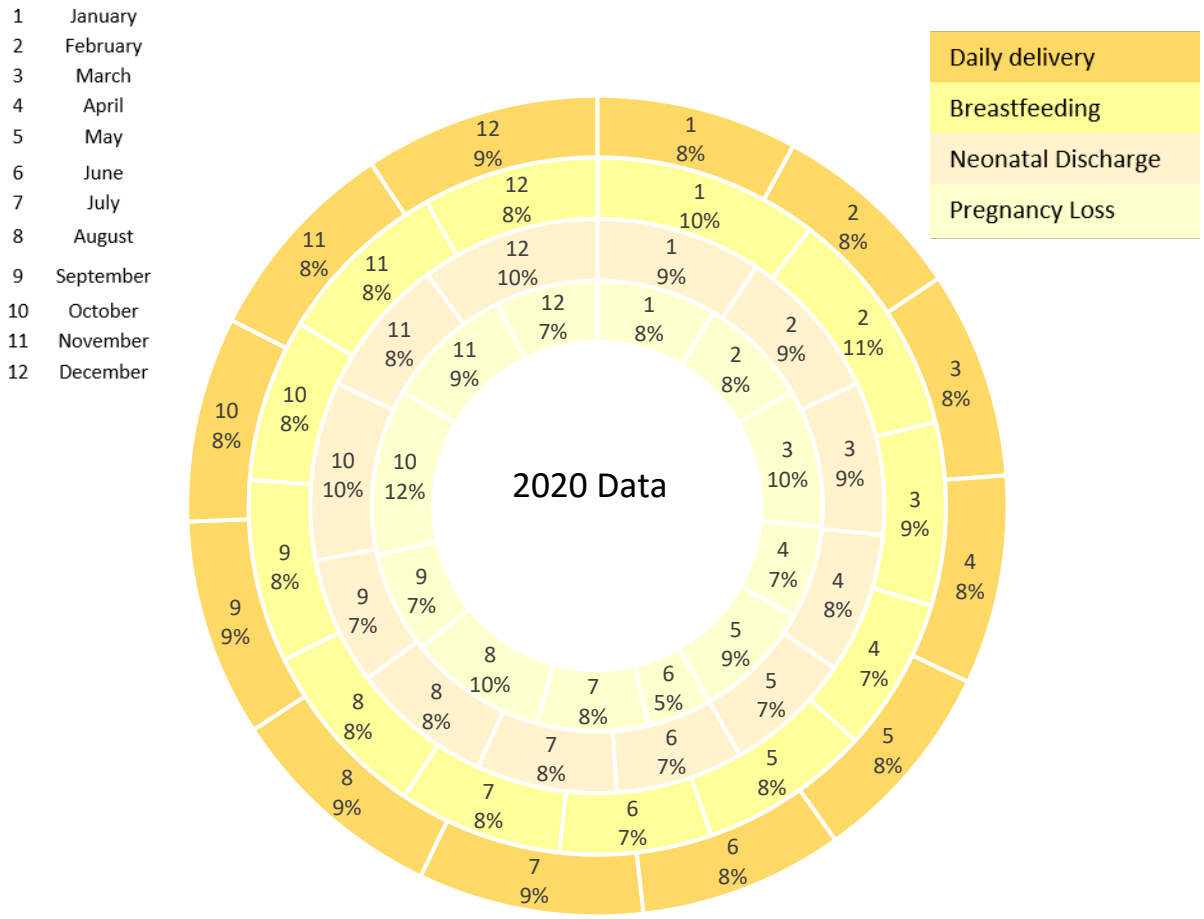


Figure 6.6: Percentage of missing data from 2020 for reports; daily delivery, breastfeeding report, neonatal discharge, and pregnancy loss report. Within the boxes the first number is the month as per the legend and the second number is the percentage of missing data points.

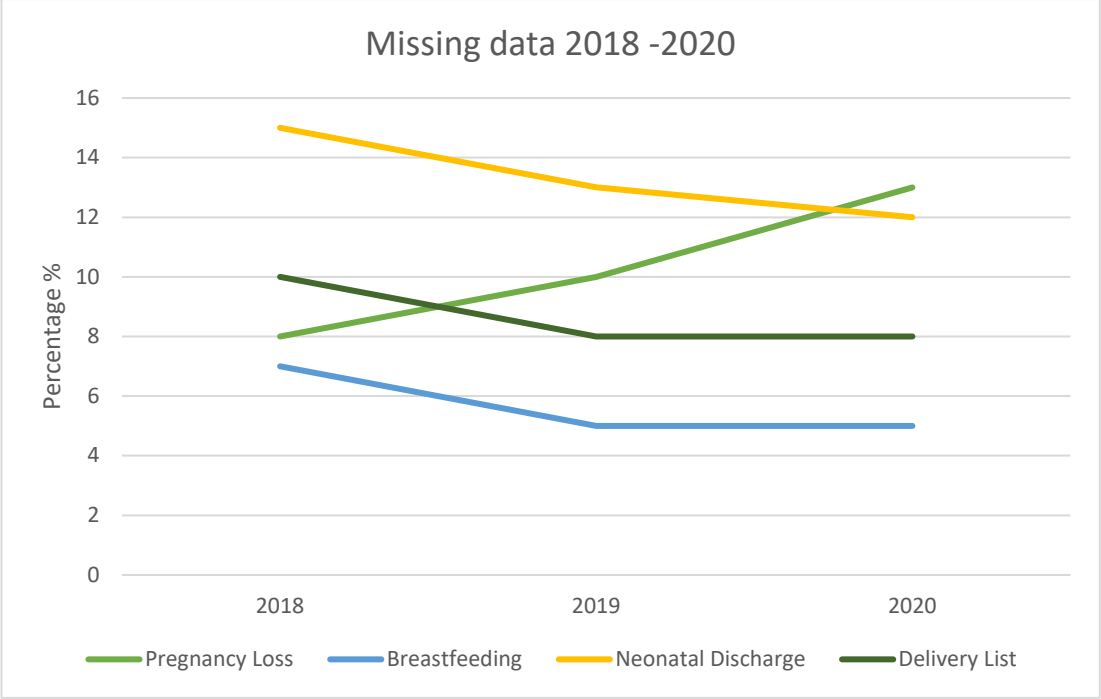


Figure 6.7: Percentage of missing data 2018 to 2020 for reports daily delivery list, breastfeeding report, neonatal discharge, and pregnancy loss report.

The above graph of the descriptive analysis of the reports shows the missing data in each report from 2018 to 2020. We can see from the graph that in the reports: daily delivery list, breastfeeding and neonatal discharge there has been an improvement but for pregnancy loss there has been an increase in missing data.

6.5 Discussion

In this project we have examined data quality by spending time investigating the data to truly understand the data quality process in the EHR. As we progressed with this project, we were able to examine from a data perspective what is it, we want and need from clinical data. It has allowed us to examine the importance of data for staff, for the primary use and the secondary use of data. Data needs to be useful; data needs to be respected and data needs to be interoperable to be merged with other data sets.[4,81] Each variable we collect needs to have a purpose - we need to understand why we are collecting it. The variables need to encompass all the dimensions of data quality. This will ensure that the data is useable for all requirements. We are collecting more and more clinical data about people that we need to remember that each variable we collect is part of the patient

information and the patient is entitled to know their data is needed, it is collected correctly, it is accurate and is the minimum required.[147, 148]

The literature on the importance of data quality in EHRs is growing and more and more researchers are addressing the need to investigate the requirements of clinical data quality.[149] There is a requirement to develop systematic methods to capture and validate the data. If we are to use clinical data for the primary use in hospitals, for patient portals and research the data needs to be standardised.[139,141]

The use of the data quality frameworks is evolving and there is a greater need to include frameworks when contemplating data development. Data frameworks provide a structure to the process and allow a team to recognise data issues early and make significant changes if required. However, before this emerging area develops further, we need to use standardised definitions and we need to ensure that people are using similar terminology. This includes staff, policy makers, and researchers.[68]

Each phase in this project has captured how we aimed to investigate missing data in an EHR. It has been useful to break the process down to a phased approach. We were able to ground the project in a data quality framework. We were able to examine each of the data quality dimensions and question how the EHR digitized data fits into each dimension. By examining the data in this framework, we are able to adjust and evolve as we gather more and more data. We are also able to critically examine if the data is fit for purpose. By ensuring we are using a data quality framework we are then able progress to auditing the data in a coherent, useful way.

Previous studies evaluating data quality primarily examined data completeness and outlined the difficulties in taking this approach. There are a number of definitions for completeness, and it is the area that attracts the most attention.[141] We have seen that the statistics community has done extensive work on missing data, how it may be considered missing, missing at random, missing completely at random or missing not at random. However, this is not sufficient for the complexities of missing data from an EHR.[58,141]There is a requirement to broaden

this and look at different elements. Weiskopf *et al* (2013) examined a dataset by using four definitions of EHR completeness: documentation, breadth, density, and predictive completeness. They showed that the number of complete records was far lower than the nominal total.[58]

Throughout this project we have taken an approach of examining completeness but understanding it from the variable perspective; by this we are showing the complexities of clinical data, which becomes more achievable when using an EHR. For each report that we extracted there is missing data; sometimes the expected variable is missing (error), at other times it is appropriately absent for that patient (correct). For some variables data quality needs to be assessed based on being a dependent variable – for example, if a patient has a caesarean section, we expect other variables such as an indication for the procedure, classification of the urgency to be documented, etc. To validate this type of data an understanding of clinical practice and documentation is needed to ensure data appropriateness.

The project looked at four reports over three years showing the data completeness in the reports monthly. This gave us an idea of times during the year when difficulties arise for staff. It also provides us with an idea about how each designated area are doing in the hospital as each report captures data at different stages of the woman and baby journey. We were encouraged to see that overall, the data has improved in the three years. We explored the monthly outcomes and provided targeted additional training and resources for the busier timeframes. There is an opportunity to further research to investigate the data by designated area and staff and by times of the day.

We identified data quality issues in the pregnancy loss documentation. The data quality in this report has declined over time and needs particular attention. Using the HIQA Data Quality framework[68] we have identified concerns around relevance, accuracy & reliability. We have made several suggestions including reviewing the dataset being captured, how it is documented and examining the purpose of what is being collected and reported. We suggested a redesign of the documentation workflow, training for staff working in the area on the data quality issues, the

workflow changes and the implementation of validation checks. We recommended that the use of this report be paused until the changes were made.

Our results identify the impact of a new data quality process including the resource of a DQM. We observed the improvement in data quality due to completion of daily data quality checks. Their workflow included feeding back to staff if items were missing and requesting the staff to update the charts. It made staff aware of the process, the value of good documentation encouraging more accurate and complete documentation in a timely manner. Furthermore, some systematic changes to the workflow and documentation of the delivery information were made following the data quality assessment. During this period a training lead was appointed and again this had an impact on optimising documentation across multiple areas of the patient journey. These changes have led to improved accuracy and reliability of the data, timeliness and coherence ensuring the EHR becomes the single source of truth with high levels of complete data. There is a need to ensure that hospital management prioritise data teams and provide resources for them. Data quality and data collection can become embedded into everyday working life for staff over a period of time.

This research project has provided a rich source of information on the complexities of data quality in the clinical setting and especially in the use of an EHR. It shows the importance of assessing data quality in a timely fashion, identifying the issues, and putting good structures and processes in place so data quality can be improved. Healthcare is at an early stage on the EHR journey, and we need to spend time finding practical solutions that ensure data quality. We have stated the importance of using a framework to assist improvements in data quality. As a healthcare system vast amounts of data are generated; harmonization of this data and processes to assure data quality, close to the documentation point are needed. The aim should be to provide high quality longitudinal data sets that are linkable, with minimal random data omissions or redundant data; this is currently not being achieved.[29]

Our work has identified in a practical way of examining data quality focussing on initial documentation practices, data completion related to individual staff

performance; the data field type may need to be changed to enhance the completion by format changes –e.g., adding a dropdown list to aid completion and accuracy. Good and timely data quality checks can identify individuals that need assistance; more generic errors requiring additional training on a workflow and documentation for all staff or indeed a re-engineering of the workflow as we identified in the pregnancy loss documentation.

6.6 Conclusion

This practical step by step approach has shown that various steps are required to improve data quality. It isn't just one element, but several factors are required. Improvement in data quality is achievable if these factors are investigated and examined. All those who work in healthcare have a role to play in data quality. We have a responsibility to collect and capture data to ensure we provide the best care and allow the best assessment of the care we provide; in doing so we are being respectful to the patient. Every person and encounter with the healthcare system needs to be treated as if the patient is going to go home and read every piece of information the staff member wrote/entered about them.

Chapter 7: An exploration of handover practices following the introduction of an Electronic Health Record (EHR)

McKernan J, Corcoran P, Greene R.

Accepted for publication MIDIRS Evidence Based Midwifery

Chapter 7: An exploration of handover practices following the introduction of an Electronic Health Record

7.1 Abstract

Background/Objectives

Communication between colleagues in a hospital setting is a vital element of their work. Clear, effective communication ensures improved work environments and improved patient outcomes. Clinical handover may improve patient safety, remove the possibility of longer stays in hospitals, clinical errors, and duplication of orders. The aim of this study is to assess the use of the EHR in the process of shift clinical handover in a maternity unit.

Methods

For this study, an ethnographic study approach was used, the process was divided into three areas, an observation study, a short staff survey and a cause-and-effect outline.

Results

The study was an exploration of handover practices following the introduction of an Electronic Health Record (EHR). Staff at handover work from a printed paper document. The document is prepared by staff on Microsoft Word and printed before handover. Staff take notes on all patients on the ward. Staff commented that they use the paper format because they like to carry the paper with them all day/night and have the data available if needed. They keep the sheet in their pockets and prefer to have all data on one sheet. A register book is also kept on the wards and number of variables are documented in writing on every patient admitted (triplicate documentation for some variables).

Conclusion

This project set out to examine why the EHR was not used at shift clinical handover and led to identifying valuable information around clinical handover. There are many steps to the implementation of an EHR. However, there are several research frameworks and developments that can impact on the process. We have been able

to use these findings to develop a step-by-step approach to a change management project plan outline to optimise the process.

Keywords:

Shift clinical handover, observation study, electronic health records (EHRs), staff involvement, ISBAR

7.2 Introduction

Communication between colleagues in a hospital setting is a vital element of their work. Clear, effective communication ensures improved work environments and improved patient outcomes. Clinical handover is defined as "*the transfer of professional responsibility and accountability for some or all aspects of care for a patient, or group of patients, to another person or professional group on a temporary or permanent basis*."[150] Effective clinical handover ensures improved patient safety, removes the possibility of longer stays in hospitals, clinical errors and duplication of orders.[151] However Milesky *et al* (2018) comment that organisations are struggling to maximise clinical handover and communication breakdowns are leading to patient harm.[152] Hospital management and staff need to recognise that effective handover takes effort and that leadership, and a systematic approach is needed.[153] Electronic health records are a longitudinal collection of patient's information including personal data, test results, medication requirements, medical history, treatment plans.[154] EHRs are becoming more and more widespread globally. The implementation process may take time but EHRs have the capacity to change health systems by improving staff practices, save money and impact on patient outcomes.[31,37,154] A clearly devised communication plan for clinical handover allows staff to maximise the time allocated. [155] The use of EHRs at clinical handover allows for the use of up-to-date information and an improvement in time management as staff do not have to type notes and prepare separate documentation at the end of the shift. There is an opportunity for staff to engage with the process and with one another more as they do not have to take notes.[152,156] Fealy *et al* comment that patients in maternity units are moved between areas several times and that effective handover is required. They observe that staff should have protected time for shift clinical handover. (Fealy et al, 2016) Protected time may not always be feasible but investigations should be carried out to explore how time can be used efficiently for handover. Changes in shift clinical handover should be beneficial for midwives allowing them to spend more time with patients.[158]

The Maternal and Newborn Clinical Management System (MN-CMS) Project is the design and implementation of an electronic health record (EHR) for all women and

babies being cared for in maternity, newborn and gynaecology services in Ireland. This record enables all maternal, newborn and gynaecology information to be shared with relevant providers of care as required in compliance with General Data Protection Regulation (GDPR).[142] The implementation of the EHR in the Irish maternity services started in the Cork University Maternity Hospital (CUMH) in December 2016. Four of the 19 maternity units are now digital, and the remaining hospitals will go live in a phased manner. The CUMH has a staff of over 600 people, the clinical staff number is about 540 people. The change from paper records to EHRs has taken time to be embedded into the everyday working life of hospital staff. Some everyday working processes have remained the same. A staff survey from the same research group showed staff were not maximizing the potential of the EHR. Eighty percent of respondents were midwifery/nursing staff and management. Medical and administrative staff all participated. Of those surveyed 50% (n=82) believed they were operating at the full extent of their education and 72% (n=106) believed their personal productivity had returned to normal. Those findings do indicate room for improvement when interacting with the chart.[159] Clinical handover is among the most important elements of the working day for midwives. The EHR has potential to reduce documentation time and make clinical handover more efficient. At staff changeover time midwives are still using a paper format to verbally hand over patients. Following the initial implementation additional training showed that optimisation and training were required. This study aimed to assess the use of the EHR in the process of shift clinical handover in a maternity unit.

7.3 Methods

For this study, the research team used the ethnographic study approach, we decided on this approach to include the staff as much as possible in the process and to really understand the culture of shift clinical handover. [160–162] We have noted that despite its potential the EHR did not appear to have been used to enhance clinical handover practices. The research team created a codebook for use throughout the project. The codes devised included people, timing, process, well-being, environment, and machine. These codes were chosen to allow us to identify changes in shift clinical handover. Following discussions with the senior

midwifery team we were asked to work with the staff from a post-natal ward. This ward was chosen because staff are allocated to this ward for a prolonged period and are very aware of ward activity. The ward is a 27-patient ward. The first element of the research was to observe the clinical handover process. At the start of every shift the midwifery staff and healthcare assistants meet for about 50mins. This occurs in the morning at 07.50hrs and again in the evening at 19.50hrs. In addition, after the handover the team engaged with the staff informally and discussed the use of the EHR and clinical handover with them.

Descriptive and reflective information were noted in the form of field notes. For the observation study the researcher sat in the room with the staff members at handover, the staff members knew the researcher was present and the notes were with a pen and paper. The notes taken included what was happening for staff, the interactions, their behaviours, what was being said and how it was said. Notes were taken on the physical surrounding as well the distractions. The notes were taken for the duration of the observations. The field notes were transcribed into a database and coded through a deductive coding process

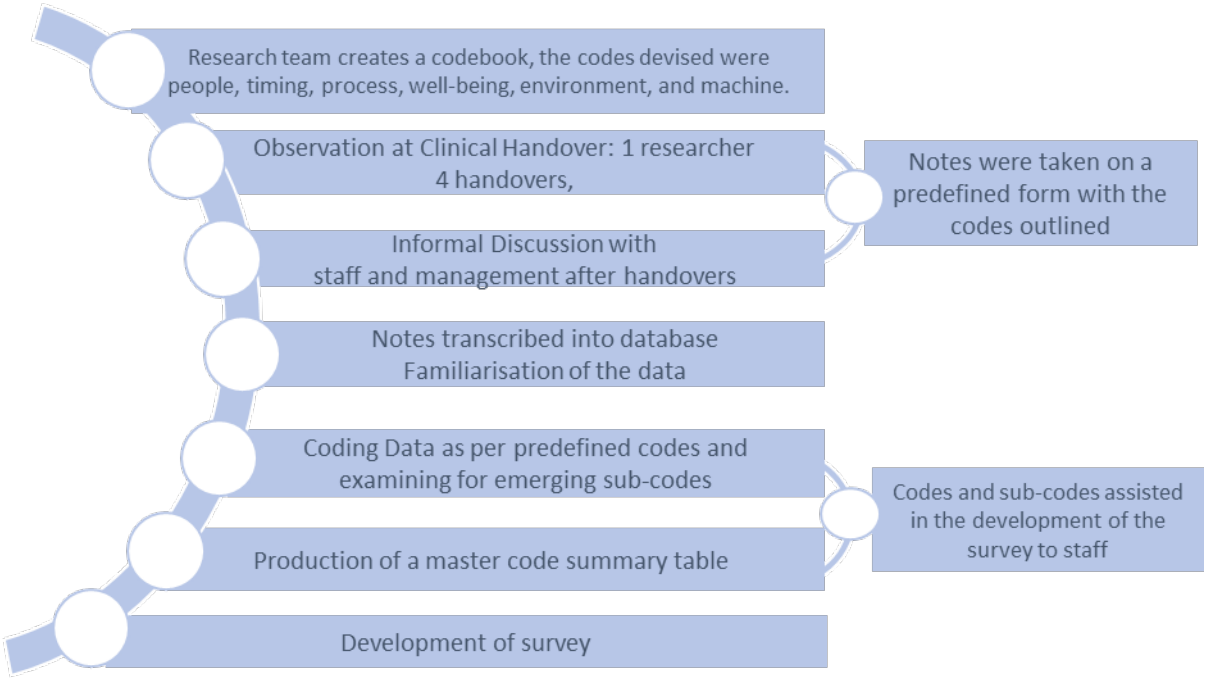


Figure 7.1: Outline of steps taken

As the findings of the observations showed the limited use of the EHR, we created a staff survey to further explore the issues/barriers regarding the adaption of the EHR. Using the predefined codes mentioned we created an 18-question survey. Hard copies of the survey were left at the midwifery station over a 6-week period. The data from the survey was transferred into the database and coded and analysed.

From the observation study and the survey, the researchers were able to devise a cause-and-effect visual diagram (Fishbone diagram) that outlined the key issues as to the non-use of the EHR during clinical handover. We were able to identify the main problems arising and discuss how best to address the issues. We followed the predefined codes for this process. It was evident from the available data that a change project plan needed to be created. The plan was presented to senior midwifery staff, training leads and staff members. The project was submitted to the executive management committee of the hospital.

This research project was approved by the Clinical Research Ethics Committee of the Cork Teaching Hospitals approval number ECM 3(yy) 18/06/19 and reviewed by the hospital Local information Governance Group.

7.4 Results:

The study was an exploration of handover practices following the introduction of an Electronic Health Record (EHR). This section presents data that shows how the aims were achieved beginning with an overview of findings.

7.4.1Observation study results:

- Staff at the handover work from a printed paper document. The document is prepared by staff on Microsoft Word and printed before handover. Staff take notes on all patients on the ward.
    - The document is divided into 7 columns that includes bed number, patient name, consultant name, Gravida/Parity, Date and time of delivery, mode of delivery and outcome issues, baby sex/weight/mode of feeding. This requires staff to double document for this process, the information is already documented on the EHR.
- Staff from the night shift hand over the patients that they have been allocated and staff from the day shift take written notes and vice versa for the handover at evening time.
- It was observed that information provided in a story format seemed more beneficial than communicating with a very structured set of variables. Staff seemed to be stressed to ensure they included all the details from the variable list but the story they told was more valuable.
- It was observed that at times a midwife may become flustered if she felt she forgot something from the word document.
- Staff write a great deal of information on the handover sheet for each patient, they write at least an additional 5/6 points per patient and spend time highlighting key points – these paper records are not maintained.
- There are care-assistants, staff midwives, student midwives present. Handover takes place in the nursery room next to the midwifery station and there may be babies present.
- During the handover process the staff can be distracted with the telephone ringing or someone looking for assistance.
- The staff finishing the night shift at handover seemed tired and distracted about tasks they needed to complete. Following the handover of patients,

the ward manager allocates the workload to each midwife and discusses plans and for the day e.g., break times, training requirements.

- Staff are not comfortable using the EHR for clinical handover. The feedback suggests they are reticent to change from the paper process.
- It was observed that staff do not see the benefit in changing from the paper version to the EHR, they noted this is the 'way it has always been done'.
- After handover staff spend time on computers checking notes and updating their printed word documents.

7.4.2 Results of staff survey:

The points outlined above were taken into consideration and a staff survey was devised to further develop the themes.

Fourteen members from this ward participated in the survey. The survey was offered to midwives and healthcare assistants. There are twenty staff members on this ward however a number of staff were not available to participate due to sick and annual leave. The survey was divided into sections:

- Description of the handover process
- Working with the EHR during the day
- Tools of the EHR
- Data and the EHR

In the first section staff were requested to describe the shift handover process and asked why they used the method of pen and paper. Staff commented that they use the paper format because they like to carry the paper with them all day/night and have the data available if needed. They keep the sheet in their pockets and prefer to have all data on one sheet. A register book is also kept on the wards and number of variables are documented in writing on every patient admitted (triplicate documentation for some variables).

Working with the EHR during the day on the ward:

- 78% of staff stated they did not have enough time to complete data when in the room with patients

- 64% of staff felt comfortable completing data entry into the EHR in the room with a patient
- 57% staff entered patient observations directly into the EHR:

Tools of the EHR

- None of the staff are using the designated midwifery patient tool for allocation and care of patients
- 75% of staff are not using the SBAR (Situation-Background-Assessment-Recommendation) formatted pages on the EHR they prefer to navigate through the chart themselves for individual staff to staff handover.

Data and the EHR

- 66% of staff can find the relevant data when handing over a patient
- 57% of staff noted that they sometimes have had to ask colleagues to complete data because it was missing or not in the place, they'd expect to find it
- 75% of staff felt that handheld devices would be useful for handover and daily documentation
- 83% agree that it would be useful to have a PC with a large screen at the midwife station with a Whiteboard with agreed patient details available
- All staff wish for further training on the SBAR section of the EHR and the designated midwifery patient tool for allocation and care of patients
- 40% of staff believe that enhancing the use of the electronic chart/MN-CMS- making it the single source of truth with data entry only once (stopping paper, word document/registers, etc.) and using it for handover would save time and would be a good outcome.

From the observation piece and staff survey we were able to develop a cause-and-effect diagram that provided us with the opportunity to highlight the key areas that require attention.

The cause-and-effect diagram is outlined in figure 7.2 and is divided into 6 areas.

- People: who does this have direct effect on, who needs to be included in any decision-making process, how do staff interact with one another.
- Timing: what time did the process start and finish, how long was the process.
- Process: how was the information delivered: systematic approach all following the same structure or was ISBAR followed
- Well-being: how did the staff seem, were they nervous, tired, emotional.
- Environment: what was the room like, did they have enough space
- EHR: was the EHR or a paper format used.

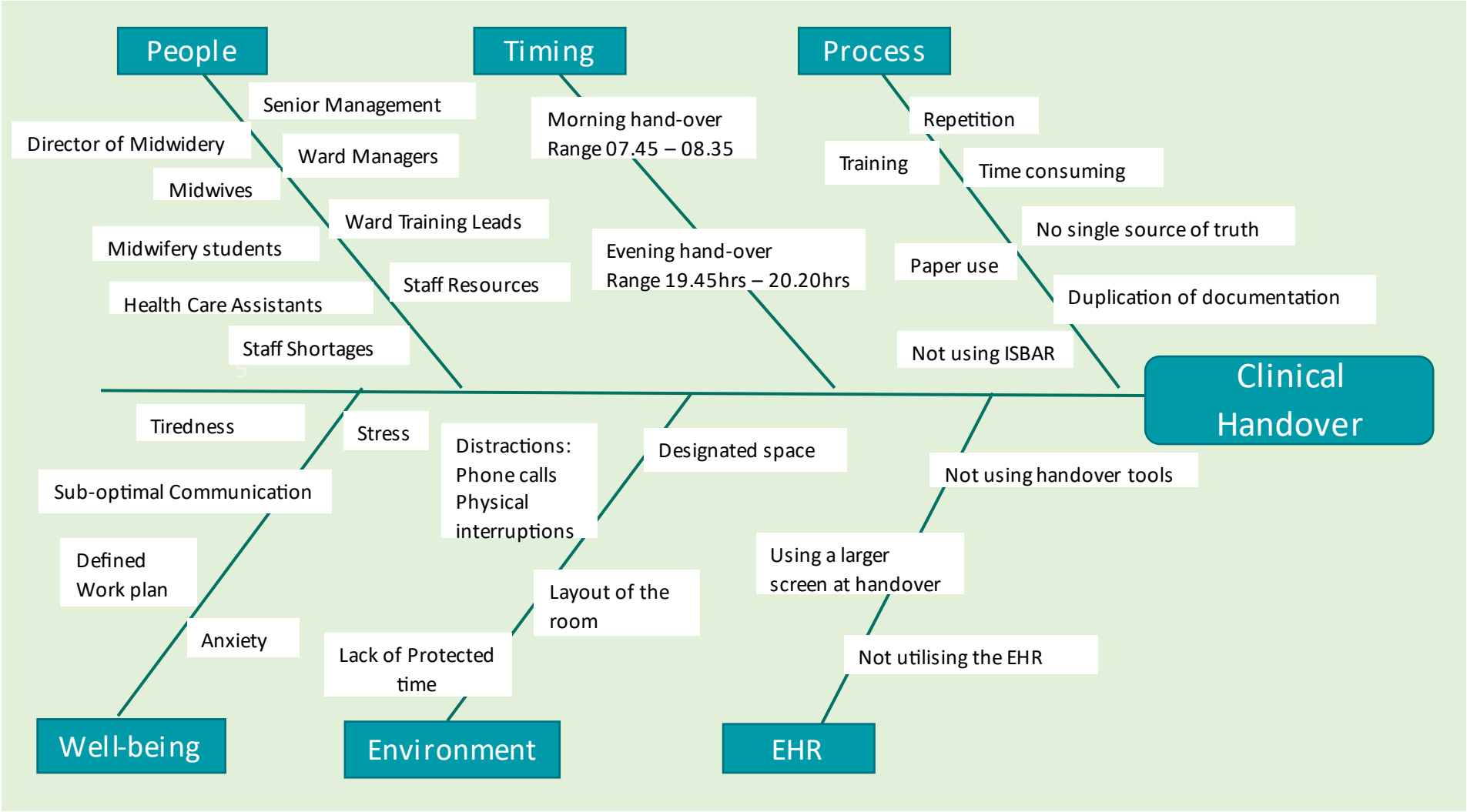


Figure 7.2: Cause and Effect Diagram

Following this process, the research team were able to devise the key factors that need to be addressed.

7.4.3 Key areas to be addressed

- Senior management need to engage in the process to support the streamlining of the use of the EHR
- At present there isn't a single source of truth because there is duplication of documentation with the register book at the ward desk, the created word document, additional writing on this document and the EHR,
- There is a requirement to optimise the SBAR tool in the EHR
- From the suggestions given by staff the training and use of SBAR and the introduction of handheld devices could improve shift handover
- Communication – there is a requirement to improve communication as there is an excess of information documentation; staff are duplicating information because they are adding similar information on some variables to the word document on one computer at the midwife station, writing on the printouts of that word document, writing on the registrar book and documenting in the EHR. This is creating well-being factors including anxiety that requires attention.
- Environment – there is a requirement for protected time and an appropriate designated uninterrupted space is needed for a quality handover

7.5 Discussion

This ethnographic approach allowed the researchers to explore the key areas that are impacting on the use of the EHR at clinical handover. This project shows that there are a number of interlinked areas that need to be addressed together. The interlinked areas include people, training, communication, the physical environment, and documentation. The National Clinical Guideline in Ireland No.5 Communication *(Clinical Handover) in Maternity Services* stated that in a previous national survey that there were several varied practices in maternity settings at clinical handover in Ireland. This guideline noted healthcare organisation need to

ensure that staff have access to relevant, up to date sources and suggested electronic patient records would be an acceptable option.[158]

The introduction and naturalization of an EHR needs time, patience, and resources. The implementation can be difficult and the process may cause issues for staff and patients.[118] It may not always be possible to use all the tools available to staff at the initial stages. However, projects can be developed to maximise the use as the integration of the chart progresses. The involvement of staff at this scoping and planning phase will ensure a greater adaption of the EHR and lead to a positive impact and improved attitude.[163] While the EHR is used for all patient documentation by the staff, we found that the EHR is not used at shift clinical handover and our research assessed the reasons why. Staff have continued to use old processes and have not optimised the tools available in the EHR. The use of clinical handover tools may improve time management, avoid repetition, and incorporate ISBAR into handover. The use of ISBAR and SBAR at handover [158] is perceived by staff as improving accuracy and quality. [164] The use of auto populated templates has been associated with a reduction in time at shift clinical handover.[151,165–168] There is also an opportunity to incorporate handheld devices into shift clinical handover by using the electronic template on the device and allowing staff to be able to access the chart during handover. We observed staff did a lot of additional writing on printed documentation and the use of hand-held devices would remove this element and ensure staff gain further confidence in the EHR, ensuring it is the single source of truth.

As staff are not using the designated EHR handover tools; a plan and training materials needs to be developed. A formalised training programme would be of benefit to staff and this may include a self-directed training programme.[152]This research identifies that a well-rounded training programme is required. A dedicated training programme can lead to the optimisation of the handover process. This type of training project can lead to the removal of barriers and improve the success of the process of handover.[169]

As shown in the results staff communication is an integral part of shift clinical handover. Staff need to ensure they are effectively handing over patient

information to colleagues. A breakdown in staff communication can be a cause of preventable patient harm.[152] Staff are comfortable using the EHR while completing tasks throughout the day however they are not aware of the handover tools available to them. The training programme suggested could incorporate elements regarding effective communication during shift handover.

Midwifery students are present for shift handover, so this is a learning process for them on how to speak to and communicate effectively with their peers and colleagues. During the observation piece it was evident that when a midwife told the story of the patient it allowed for greater engagement in the handover process. We suggest that any process improvement must maintain the capacity for the midwife to tell the story and ensure it is included in the documentation. Using the EHR tools for clinical handover ensures all have the details at their hand and can focus on the story and human factors, enhancing the quality of the handover.

Shift handover takes place in the nursery room next to the midwifery station. This can be a busy area with little space and staff are interrupted regularly. It is important for staff to have protected and uninterrupted time for this part of their work. Lang *et al* (2019) commented that the accessibility of information may have an impact on staff discussion and decision making.[170] The handover process may be used more effectively if staff feel they have a safe, comfortable designated space for this task.[171]

This step back approach to the research question was necessary as we identified that the EHR was not being used. Shift Clinical handover is an essential element for midwifery/nursing staff. We have gained knowledge on shift clinical handover and the use of the EHR. We have been able to recognise the time required for implementation and we identified that staff at all levels need to be included in the process. Future research areas may include how does shift clinical handover effect patient care. A significant point of learning is the value of this extended type of research to assess complex clinical activities. We gained significant valuable information following identification of codes/themes in the ethnographic study which we then used to direct questions for the staff survey. The cause-and-effect

diagram does put the staff at the centre and is a tool that provides a definite view of the issues. This extended approach would be valuable in the assessment of the implementation of EHRs with staff and how to move the project towards the optimisation phase.

7.6 Conclusion

There are many steps to the implementation of an EHR. However, there are several research frameworks and developments that can impact on the process. This project set out to examine why the EHR was not used at shift clinical handover and led to identifying valuable information around clinical handover. We have been able to use these findings to develop a step-by-step approach to a change management project plan to optimise the process. The staff were central to the development of the plan. The plan outline is shown in figure 7.3 and incorporates a full evaluation of the process. The plan outline has five areas of focus: changes at clinical handover, training, communication, environment, and evaluation. Each area of focus is divided into elements that need to be changed or addressed. Working with staff members we have been able to develop a complete and comprehensive project management plan for each of the areas of focus. This process has been hugely beneficial for staff members as they have been able to break down every step in the process examining any areas of concern.

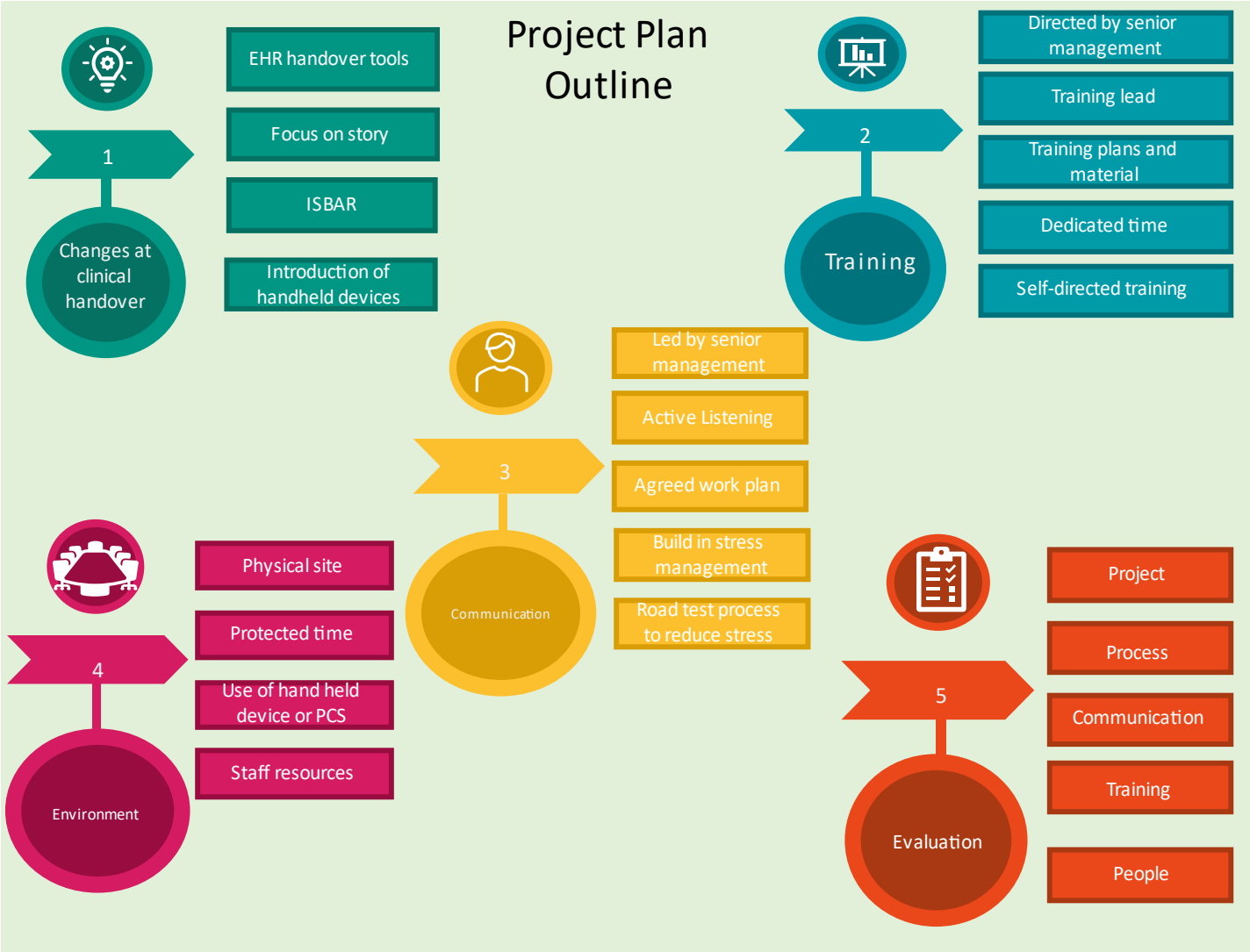


Figure 7.3: Project Plan Outline

Chapter 8: Discussion

Chapter 8: Discussion

8.1 Introduction

In 2019 €23.8 billion, which is equivalent to 6.7% of GDP, equal to €4,836 per person, was spent on Healthcare in Ireland.[172] The World Health Organisation in *Global spending on health: Weathering the storm* noted that pre-COVID-19 pandemic the health spending was continuing to grow, and in 2018, it had reached US$ 8.3 trillion, or 10% of global GDP.[173] The impact of the COVID-19 pandemic is still uncertain on health spending, and it could signify that there is now even a greater need to finance systems and protect vulnerable populations.[173]As the COVID-19 pandemic is still ongoing, it has been highlighted that we need agile healthcare systems that can adapt to all global needs. It may also lead to a change in what health professionals and staff expect from systems and data. Real time data may drive policy and operational decisions from senior management and lead to a data-driven learning health system. The effects of the COVID-19 pandemic on healthcare systems will take experts a while to unravel.[174] The Department of Health in Ireland 2021 -2023 statement of strategy outlines; that the vision is for *"A healthier Ireland, with improved health and wellbeing for all, and with the right care delivered in the right place at the right time."*[175] One of the five key enablers of the strategy is data, technology, and digitisation, they envisage that *"advancement in health systems information, and innovations in technology and digitisation, are vital in underpinning an evidence-based approach to policymaking that is person-centred and delivers on strategic priorities. Data is also of crucial importance to government for supporting decision-making, shaping policy and facilitating the effective delivery of public services.*"[175] Sláintecare is the cross-party initiative that aims to transform the Irish Healthcare system in the next 10 years with the aim to deliver a universal health service that offers the right care, in the right place, at the right time, at low or no cost.[9] The strategy document (Sláintecare Implementation Strategy and Action Plan 2021-2023) outlines the importance of the eHealth Programme and states that it "is a critical enabler of the Sláintecare Reform Programmes, and significant investment in eHealth capital and staffing will be available for implementation over the course of this Strategic Action Plan.[9] The Sláintecare Implementation Plan states that ICT (information and

communications technology) "*ICT has the potential to be the biggest and most effective driver of change and improvement for better patient outcomes across the health system. In the future, a coherent suite of eHealth solutions will underpin and support our overall vision for integrated, patient-centred care, population health planning and more effective and safe delivery of health services. Patients and health professionals will have ready access to clinical records and administrative information, which will enable better decisions to be made."*[9]

The global pandemic has made us think about what we require and need. In Ireland, following the cyber attack on the Health Service Executive (HSE), we need to be able to update hardware and software, increase security and restore public confidence. The Health Information and Quality Authority (HIQA) in Ireland states that we have not invested in health information compared to other European countries and note that *" There is a need to consider developing a Health Information Strategy that takes a holistic and cohesive approach to managing health information, that is,- how health information is collected, used and shared for not only primary care purposes but also for secondary use and research purposes across public and private healthcare*".[52] The Irish Healthcare system needs to have a fully integrated system that takes us throughout life; it should link all services to ensure safe care, allow patients to use and access their information and ensure data is accurate.[176] In the current scenario with the absence of joined-up data systems, the use of paper systems, and with many people/departments working in silos, there is the potential for risk, waste, and overspending. These clinical/business risks include:

- Duplication of data, laboratory tests, radiological studies, medical prescriptions
- Risk of patient injury – non-aligned clinical information – clinical staff may not have access to important information documented by other healthcare professionals – e.g., allergies, errors can happen at transitions of care if a complete medication list is not clearly communicated
- Staff risk – poor systems/poor information – poor decisions
- Data breaches and loss of trust

The energy spent trying to link systems and working on outdated software is not how a quality healthcare system can be built.[177] We need a healthcare system that ensures staff members have the best systems and equipment available to them. To fully develop and optimize these systems, staff involvement is required.[43,78,178] In contrast in a well-organized and digitized health service information follows the patient – providing the right data about the right patient in the right place at the right time. It allows integration of services across care settings – leading to safer care and over time reduced cost. It ensures better data and better decisions for patients and the health system. For the patient/service user – there is a comprehensive picture of their healthcare information leading to more informed and engaged patients and citizens and enhanced value for their care over time. There are models in the UK, Finland, and Denmark that we could learn from and adapt.[52] In the report *Developments in Healthcare Information Systems in Ireland and Internationally 2021* this report provides an overview of what is happening internationally and what we could learn in particular from Scotland, Estonia and Denmark.[8]

The European Commission has launched the *European Health Union: A European Health Data Space for people and science (EHDS). The EHDS "is a health-specific data sharing framework establishing clear rules, common standards and practices, infrastructures and a governance framework for the use of electronic health data by patients and for research, innovation, policy making, patient safety, statistics or regulatory purposes."*[10] The EHDS aims to allow individuals to fully exercise their rights over their data so that is can be shared be easily accessible and this will be in line with data protection regulations. This should allow for the shared health data across borders for staff it means that health data will be improved by better interoperability.[10] There is a move towards improving health data is that it can be available for individuals which will allow them to be shared decision makers in their health.

The research undertaken as part of this thesis focussed on aspects of digitisation that go towards achieving a high-quality data repository. I undertook studies that aimed to investigate the development and use of an EHR in the Irish healthcare

system with specific consideration to elements that are important for data quality. We examined the experiences of the development team, patients, staff, service culture, and data. From these studies, I developed the main themes of this project.

These include:

1) The key considerations in developing an EHR

2) Patients views and requirements around digital healthcare

3) Staff Perceptions following the implementation of the EHR

4) Standardised Frameworks

5) Data Quality Assessment and Improvement

6) Service culture and its effects on aligned data use

Each study has a place in this overall examination as it builds the elements that are necessary for good data quality. For the author an understanding of the implementation of MN-CMS was required; why move to an EHR? how does it provide data and what data can it provide? From examining the implementation of the MN-CMS one key point that needed to be explored was how patients feel about data and the MN-CMS. As I continued through the research process and to get a better understanding of the data it was necessary to survey the staff in the unit. An understanding of staff documentation practices was required to understand how the data was collected. Examining data quality is challenging and examining data using a data quality framework was necessary to understand the dimensions of data quality. It was necessary to undertake a data quality assessment of that data captured in the EHR and to see how an intervention would impact on the data quality. Finally following the data assessment piece, it was deemed necessary to explore how work culture impacted on data quality. Each stage of the research process led nicely from one area to the other and it showed how research evolves and that is necessary to be adaptable to what the research is showing.

These themes reveal several essential factors about digitizing clinical data and digital health. We will discuss these themes separately, examining the implications

for clinical practice and healthcare policy. Each theme outlined will include a section proposing recommendations for future research.

8.2 The key considerations in developing an EHR

In chapter 2 of this thesis, I outlined and presented the lessons learned and key recommendations from the closure report of the national project team of the Maternal & Newborn Clinical Management (MN-CMS) a complete EHR used for maternity services in Ireland. This report summarized key elements that can be used widely. EHRs are being developed and introduced at an unprecedented rate in many countries.[19] Several countries have had varied success with implementation through to optimization stages.[43,19] EHRs can change healthcare by saving money, improving communication, and reducing errors. The introduction of an EHR is a substantial change management project that needs to include all stakeholders to ensure success. The introduction of an EHR requires vision, dedication, time, and patience. It needs to be well resourced financially by increasing staff and upskilling them in relevant areas.[179] The MN-CMS development is an example of a clinician-led, patient-focused, change management project. The project team ensured patient care was at the core of the development and implementation. This research provided an opportunity to understand the implementation of MN-CMS and to garner knowledge on what could be the benefits of the introduction of MN-CMS in relation to data and data quality.

8.2.1 Main findings

The main findings from this project are an example of an EHR system used in digital health. Examining MN-CMS through this report and anecdotal evidence from discussion with the obstetric lead of the MN-CMS project showed some of the factors that impact data in a system; these include patients, staff communication, training, information governance, leadership. All these elements need to be aligned to ensure that data can be used to improve patient outcomes and care. The main findings include

- Engage key stakeholders early in the process

- Strong leadership including clinical leadership is needed for decision-making
- Take time for the procurement process
- Set up a governance structure
- Communicate with staff about the project and engage with interested parties
- Remember to always keep the patient at the center of the project
- Ensure multidisciplinary team (especially senior medical staff) involvement as early in the process as possible and tailor the involvement for each staff member
- Spend time developing the workstreams to ensure they cover the necessary aspects
- Limit the changes required to the system and control the changes required with a weekly meeting
- Go live: is when it will show what works and what can be improved
- Ensure optimization teams are in place before the project goes live
- Keep your go-live trainers involved to increase the functionality and optimization of the chart
- Ensure an information governance structure is in place for all data requirements
- Ensure staff have mechanisms to feedback about the EHR: staff survey, feedback clinics
- Ensure patient access to their records via a patient portal

8.2.2 Implications for clinical practice

EHRs allow staff to move to a paperless workspace so that all information relevant to the patient is accessible in one place. More than one staff member can access the same chart at the same time, the individuals can be in different areas within a healthcare facility or geographically and can be documenting or examining the information. The EHR can lead to a reduction in care errors with appropriate up-to-date and available information supported with good clinical decision support. There is enhanced data governance and data management with an audit trail of

staff accessing information. The systematic data collection configured in EHRs can improve data collection as they have required structured points. The issue of illegible written notes is no longer a problem and staff can provide and access a multidisciplinary care plan for the patient. The improvement in patient documentation leads to better communication between staff members, and this improved communication allows the team to focus on the patient's care.

8.2.3 Healthcare policy

The Department of Health in Ireland is in a good place to coordinate and develop digital health projects. Other countries have learned valuable lessons for example the issue of EHR interoperability is becoming more and more of a concern; the USA has seen a number of issues arise in this area and have spent billions on trying to connect systems, there are numerous systems in use across the states using different terminology with different specifications and capabilities.[12,180] In Ireland we may not have a complete EHR for everyone but we have a number of systems (e.g. General Practice (GP) data, Patient Administration data, laboratory results) being used that could be linked together and function as a health record. Li *et al* (2021) comment that in the UK there is a concern for patient safety and cost to the healthcare system without EHR interoperability. The risks include medication errors, poor data quality, and redundant testing for the patients.[181]

This provides an opportunity to learn and enhance what can be done. There is a need for government to provide funding for the development of digital health that includes, hardware and software upgrades, staff, training, and a requirement to further expand multidisciplinary teams to include data managers and data analysts. The government and Department of Health need to ensure all staff areas are well resourced; there is a need to ensure that any healthcare IT project can be easily optimised and linked. There is a requirement that projects are clinically led, including all relevant stakeholders from the beginning of the project. A project team needs to be adaptable and evolve as the project progresses. All individuals deserve a well-connected, easily accessible healthcare system that reduces risk.[182]

8.2.4 Recommendations for future research

There is a need for research on the impact of digital health projects and EHRs on workflows for staff, the changing relationship between patients and healthcare professionals, and the effect on decision-making by clinicians.[182] For maternity services in Ireland there is a need to examine the implementation of the EHR, examining barriers moving from the implementation to optimization phases. This piece of work could be commissioned by the MN-CMS national project team to highlight the strengths of the project and maximise further development.

8.3 Patients views and requirements around digital healthcare

8.3.1 Main findings

In chapter three of this thesis, we found that patients want access to their charts which they believe would provide them with ownership of their health information; they believed their personal information is safe in the new computer system. Eighty-one percent of participants would like access online to their charts and noted the impact the EHR could have on clinic time and interactions with staff. Patients in this study were very receptive to the introduction of EHR and noted that it would be beneficial for their care. Patient satisfaction plays a key role in the further development of the EHRs as one component of healthcare. For some countries merging the patient portal element and the implementation of the EHR may allow a complete patient-centered chart to be developed. HIQA carried out a National Public Engagement on Health Information and found similar results. "*1,058 people (86%) think that it is important or very important to be able to access and view their own medical records online"*[183] *"People have high levels of trust that their information will be kept safe and secure when it is used for these purposes. 961 people (79%) trust that their health information will be kept safe and secure if it is used for improving the quality of care. 941 people (77%) trust that their health information will be kept safe and secure if it is used to plan healthcare services."*[183] HIQA also found that the people would like to know who has accessed their records and that people had concerns about some sensitive data being shared that may not be relevant to a particular point of care.[183] Our study shows the importance of patients in the development of EHRs and digital health projects. Patients need to be central to their care, and some EHRs have developed without

patient input or keeping patients at the centre.[178] The MN-CMS project in Ireland is an example of a patient-centered electronic chart. All aspects of the patient's care are connected, and the multidisciplinary team can use the chart to ensure high-level, safe care. Data is available about the patient from their first encounter until they leave the hospital.[87] Patients want to actively be able to access their charts and interact with their notes,[50] which is fundamental to the long-term goals of digital healthcare in Ireland.[184]

8.3.2 Implications for Clinical practice

Digital healthcare will lead to transformations in healthcare for patients; it may provide opportunities for better outcomes.[185] We are now using our smartphones and digital devices more every day, and this will allow patients to interact with their healthcare providers virtually and monitor their health in greater detail. This will involve patients becoming more involved in their care may lead to patients taking ownership of their care. For clinical practice, this will involve staff improving documentation so that data can be shared on patient portals thus improving the overall quality of data. Documentation from staff may improve as they know data will be shared with patients and patients may feedback on inaccurate data.

8.3.3 Healthcare policy

HIQA found in their study *National Public Engagement on Health Information* that "*there is a need for comprehensive national policy and legislation in relation to health information. There is also currently a lack of clarity around an appropriate consent model for the collection, use, and sharing of personal health information. As new digital technologies for healthcare, such as electronic health records and patient portals, are introduced, it is essential that a robust consent model is in place to ensure good information management practices and to provide assurance that people's rights in relation to privacy and confidentiality will be upheld."*[183] Following this engagement there is a requirement to ensure funding is provided to achieve these goals.

8.3.4 Recommendations for future research

We need to consider research in the area of digital healthcare and its effect on the interaction with patients. There is a need to explore co-designed patient portals

to examine the interaction between patients and HealthCare Professionals (HCPs) and the interaction with their data. We need to examine patient and HCPs consultations to see if there are areas for improvement and enhancement.[186] There is an opportunity for digital departments within the health service to examine the role of the patient and digital healthcare.

8.4 Staff Perceptions following the implementation of the EHR

8.4.1 Main findings

In chapter four of this thesis, we highlighted the complexity of implementing an electronic health record for staff. We showed the many factors that need to be considered to ensure staff members are engaging with the EHR. Staff engagement is key to the success of the EHR. Staff members were asked to comment on their experience and four themes emerged; these included: issues with logging into the system, training requirements, improvement in-patient care, and documentation. Staff commented that documentation had improved and was now legible however there were still issues evident. Nearly 60% (n=100) of participants were happy with the implementation of the EHR and 50% (n=82) believed they were operating at the full extent of their education and 72% (n=106) believed their personal productivity had returned to normal.

The staff members were asked to agree or disagree with a list of statements regarding their primary concerns and 60% (n=72) of them felt that their colleagues had difficulties utilising the EHR. Nearly 35% (n=39) of staff felt that the EHR slowed them down, and that additional time was needed to complete documentation. 85% (n= 99) of staff were comfortable using the EHR in front of patients. Staff members need to be a part of all elements of the development, implementation, and optimization of an EHR. They are integral to the success of the project. Implementing an EHR takes time and needs to be well-resourced, and continuous staff training is required. With such a significant project, staff engagement is vital; staff members need to be leaders in the process. In some cases, we found some negativity from staff members, this can lead to old workflows being used and a delay in the process. From this, the potential of the EHR can be negatively impacted. This thesis has shown that using practical mixed

methodologies to explore the impact of staff utilizing the chart can provide robust solutions. Mixed methodologies allow staff to provide learning points as the project develops.

8.4.2 Implications for Clinical practice

In a healthcare setting, staff members have several roles: care providers, problem solvers, and they document the care provided. They must keep up to date on clinical guidelines and practices, and change can be slow. [187] Documentation is an essential part of patient care; however, because the EHR allows data to be used more effectively and efficiently, staff members must improve their documentation. There is a requirement to retrain staff members on the importance of documentation to understand how data can be used from the EHR.[188,189,28] During the implementation process, staff members need to recognize how the introduction of an EHR, and other digital projects may improve their working life. This element should be included in their training. There may be a requirement to provide staff with implementation and evaluation science fundamentals.

8.4.3 Healthcare policy

There is a need for the inclusion of all staff groups in the implementation of the EHR; different staff levels need to be included so that a range of topics and issues pertinent to their work can be addressed and discussed. Staff members need to be assisted in taking ownership of this scale of a project and understanding the benefits of an EHR and digital health projects. There is a need for policy makers to understand this demand and fund involvement in the implementation. An EHR allows for improved data collection; multidisciplinary communication is easier to achieve.[28] It should be required that senior hospital management address this issue and explore how staff members can maximize the EHR to learn and grow as healthcare professionals. Staff members can be resistant to change, and it is essential to break down why this is a recurring issue for healthcare policy development.

8.4.4 Recommendations for future research

This thesis outlined mixed methodologies to explore the impact of the implementation on an EHR. These projects have shown that staff members are an integral part of a project, and there is a requirement to learn what works and does not work for them[159]; these aspects offer a lot of room for future research. Similarly work processes and workflows need to be examined, including investigating staff documentation and staff understanding of data. Staff members need to be a part of the project's design and should be encouraged to improve continuously by examining and evaluating what works in the EHR.[190] This research could begin within universities that further explores multidisciplinary mixed methodologies approaches to change management projects.

8.5 Standardized Frameworks

8.5.1 Main findings

In chapters five and six of this thesis, we used the Health Information Quality Authority (HIQA) data quality framework for this project, and it showed the importance of following a defined national body to examine data. The HIQA framework is an internationally researched piece of work that consolidates the theories of similar frameworks and provides a useable framework to maintain data quality standards. It is a data quality assessment tool, based on the Canadian Institute for Health Information (CIHI's), the Information Quality Framework (IQF), and the Generic Statistical Business Process Model (GSBPM).[68] The adaptation of the assessment tool provided structure for a marking system to be developed. It allowed for a structure to be in place that can be used again. The dimensions relevance, accuracy and reliability, timeliness and punctuality, coherence and comparability, and accessibility and clarity can be analysed. The data can improve as the data audit cycle progresses. Data quality audits provide a structure to continually assess data whatever the topic. It is important to continue with a well-defined structure to improve data capture and data documentation and maintain the continuous approach of improvement. This thesis showed a requirement to develop standardized frameworks for data quality projects. In chapter five examining a dataset from a national audit perspective allowed the researcher to understand the importance of outlining a process and underpinning work in a well-

thought-out framework. In chapter six we explored data quality from an EHR and suggested improvements from a practical perspective. This approach allowed for a greater understanding of the importance of frameworks and how they can impact the success of a project.

8.5.2 Implications for Clinical practice

Standardized frameworks may allow staff greater engagement in EHRs and better understand their requirements. Developing frameworks that suit the needs of the hospital staff and hospital management may improve documentation, data collection, and overall knowledge of data quality. Using a framework structure towards good data quality, may improve patient outcomes as staff may have more time to spend with patients. Improvements could be made in data completion, lowering risk, and improving overall care.

8.5.3 Healthcare policy

We used the Health Information Quality Authority (HIQA) data quality framework for this project, and it showed the importance of following a defined national body to examine data.[68] There is a requirement for all data collections either national, regional or local to follow the standards and policies set out by HIQA. All staff should be aware of their policies and standards and this should be resourced. There is a need for policymakers to agree on terminology for frameworks and ensure people use these sets of definitions.

8.5.4 Recommendations for future research

There is a necessity for further research on how frameworks could be used to assess implications for data collection, data quality in the digitisation of health data, and how this work could enhance documentation quality for staff. There is a need to apply a data quality framework to more and more datasets.[146,191] Several different terminologies are being used within the literature that impact data quality. Researchers are spending more and more time developing frameworks, and it may be of greater importance to agree on definitions and principles. There is a need to examine how researchers could maximize healthcare data for secondary use by applying a framework to primary data.[192] There is an advantage

in using developed national frameworks, it may be interesting to investigate if others have used the HIQA framework and to combine the learning.[193,177]

8.6 Data Quality Assessment and Improvement

8.6.1 Main findings

Chapters 5 and 6 of this thesis outlined areas impacting data quality. Data quality is defined by HIQA as "*Data that are complete, valid, accurate, reliable, relevant, legible and available in a timely manner."*[52] We used a data quality framework to examine these issues. We outlined the importance of a well-resourced system requiring clinicians to validate data completeness and accuracy. We outlined some emerging issues, including the importance of enabling data capture and the phrasing of questions to assist accurate data. We outlined a practical approach to address these issues. Staff members need to be trained to input data, understand the value of good data for patient care and the data needs to be validated with feedback to HCP's in a cycle of continuous improvement.[194] As HIQA comments the " ultimate goal is to collect health information once and reuse it many times for different purposes. There is significant potential for use of clinical data beyond its primary intent of patient care.[52]

8.6.2 Implications for Clinical practice

Staff members should be required to capture, and quality assure the data they document. This may be helped by providing feedback from the data in EHRs, appropriate to their area of work. Quality data from an EHR and a nationally collected data set improves patient outcomes and care. HCPs should realize that data may need to be validated, which should be part of their work plan for the day. Quality data can improve care and provide management with an outline of services and clinical requirements. If data is collected well and validated, it could impact all areas of clinical practice. Quality data leads to information that leads to intelligence.[59]

8.6.3 Healthcare policy

All government providers should be ensuring quality data from healthcare settings. The benefits of quality data can improve care, reduce cost, and streamline work practices. The COVID-19 pandemic shows that healthcare

systems now use up-to-date quality data for policy decisions. The move towards using data for decision-making needs to be continued and resourced in all areas of healthcare. HIQA in a recent report reviewing five national data collections for compliance against the information management standards found that there are a number of key challenges that need to be addressed. These include "*governance, leadership and management arrangements of these national data collections, as well as in relation to information governance, data quality and the effective use of information*" [52] They found a lack of robust "*governance arrangements to ensure the quality of data and effective use of information."*[52]

Healthcare students need to be taking modules on data quality and data quality frameworks. There is a need for staff and students to complete education in data structures, data quality, data use modules, informatics, and data analytics. Healthcare organisations need to train staff on data use, data collection, and data validation. Staff members need to have the most up-to-date hardware and software versions, e.g., Excel, available to them.[195]

8.6.4 Recommendations for future research

Data quality is a growing area of research interest, and we need to have processes to address the arising issues. We are now collecting vast quantities of Big Data, and the more data we have, the more machines and software may be able to do more with it. However, we need more research in approaches to improving the baseline data quality at the documentation phase. There is a good theoretical base for data quality assessment, but greater effort is needed in approaches to enhance end-user documentation. For the individual healthcare user, their data documentation should be complete and accurate for their immediate use; they also need to have a clear understanding of the importance of high-quality data to the improvement of services for the patient and them as employees. We need to examine the structures of the staff-data interfaces; we need to research the impact of missing data on patient care and the healthcare service and its evaluation. All national data collection centres should explore data quality and the elements relevant to them.

8.7 Service culture and its effects on aligned data use

8.7.1 Main findings

In chapter seven of this thesis, we explored shift clinical handover following the introduction of an EHR, this led to identifying valuable information around clinical handover. Staff at handover work from a printed paper document. The document is prepared by staff on Microsoft Word and printed before handover. Staff members take notes on all patients on the ward. Staff commented that they use the paper format because they like to carry the paper with them all day/night and have the data available if needed. They keep the sheet in their pockets and prefer to have all data on one sheet. A register book is also kept on the wards and a number of variables are documented in writing on every patient admitted (triplicate documentation for some variables). As mentioned in the previous sections the aim should be to collect data once and reuse it several times. This maternity unit examined in this thesis was completely paper based before the introduction of the EHR and this may explain why this culture remained.

8.7.2 Implications for Clinical practice

For this piece of work, we worked closely with staff members to try and understand why the practices were still being carried out. Working with staff members we have been able to develop a complete and comprehensive project management plan for each of the areas of focus. We have proposed a project plan that included changes such as: Introduction, Situation, Background, Assessment, and Recommendation (ISBAR) use at clinical handover, training, communication, environment, and evaluation. Each area of focus is divided into elements that need to be changed or addressed. The use of ISBAR would focus on the data being shared and may improve the quality of data entered in the chart as staff members would be ensuring to complete fields that they know need to be used for handover.

8.7.3 Healthcare policy

There is a requirement to keep guidelines up to date to include ISBAR with an EHR and ensure it is being used. Senior management should ensure staff members are not duplicating data or duplicating effort. Senior management should examine the service culture in their areas and examine how best to impact change to ensure

the projects are well-received by all members of staff. There is a need to include staff members more in change projects and engagement with staff with improved communication may impact the outcomes of the project.

8.7.4 Recommendations for future research

Research is required around workplace culture and how best to implement, optimise and evaluate projects. We further need to examine service culture and its effects on aligned data use. We were able to look at one area, however, there are other areas where research on data capture may be valuable, e.g., obstetric emergencies, neonatal intensive care, medication use processes, lab ordering. Hospital senior management have a role in examining how workplace culture is impacting on the success if change within the unit.

8.8 Strengths and limitations

This thesis aimed to explore elements of data quality in digital health, using qualitative and quantitative methods, focussed on an EHR. We believed this approach was necessary to understand the issues and provide recommendations. The use of different methodologies provided the researcher with a knowledge of what is required to fully capture results beneficial for change. One of the limitations of this thesis is that the projects were undertaken on one site and only using maternity data. However, we felt it appropriate to use the Cork University Maternity Hospital as the EHR was implemented in this hospital initially, allowing it to be embedded more with staff, and we could carry out more extensive research.

8.9 Conclusion

The objective of this project was to explore the impacts of digital health, particularly examining the impact on patients, staff, and specifically to examine the area of data quality. This thesis has shown a need to move towards standardised terminology and methodologies to achieve these goals and the projects have shown that practical solutions are required. We have shown the importance of staff members and their role in the success of the project implementation. We have highlighted the importance of the use of frameworks to really assess data quality. There are growing areas in the literature regarding EHRs

and data quality, but more significant work is needed. As outlined, further research is needed in several areas.

As a result of this thesis, we have seen local changes to the hospital environment and clinical practice; in particular, the data validation process has been updated. We have also been able to work with the senior management about potential improvements to care and better use of data in the clinical handover project. We have also shared the outcomes of the projects and suggested methodologies with other hospitals nationally and learning points will be used as the implementation process continues.

References

References

1. Pearson K. The Life, Letters and Labours of Francis Galton. Published 1924. https://galton.org/pearson/

2. Maindonald J, Richardson AM. This passionate study: A dialogue with Florence Nightingale. J Stat Educ. 2004;12(1). doi:10.1080/10691898.2004.11910718

3. Thomas H. Davenport, A. Blanton Godfrey and TCR. To Fight Pandemics, We Need Better Data. https://sloanreview.mit.edu/article/to-fight-pandemics-we-need-better-data/

4. Dash S, Shakyawar SK, Sharma M, Kaushik S. Big data in healthcare: management, analysis and future prospects. J Big Data. 2019;6(1):1-25. doi:10.1186/s40537-019-0217-0

5. Panoho K. The Age Of Analytics And The Importance Of Data Quality. https://www.forbes.com/sites/forbesagencycouncil/2019/10/01/the-age-of-analytics-and-the-importance-of-data-quality/?sh=39fd9b555c3c

6. Why is health data important? — Data Saves Lives. https://datasaveslives.eu/why-is-health-data-important

7. Subrahmanya SVG, Shetty DK, Patil V, et al. The role of data science in healthcare advancements: applications, benefits, and future prospects. Ir J Med Sci. Published online August 16, 2021:1-11. doi:10.1007/S11845-021-02730-Z/FIGURES/5

8. Walsh B, Mohan G. Evidence for Policy DEVELOPMENTS IN HEALTHCARE INFORMATION SYSTEMS IN IRELAND AND INTERNATIONALLY . Esri Surv Stat Rep Ser Number 105. Published online 2021. https://doi.org/10.26504/sustat105

9. Department of Health. Sláintecare Implementation Strategy and Action Plan 2021-2023. https://www.gov.ie/en/publication/6996b-slaintecare-implementation-strategy-and-action-plan-2021-2023/

10. EU Health: European Health Data Space. https://ec.europa.eu/commission/presscorner/detail/en/QANDA_22_2712

11. Vinod Khosla on the Future of Healthcare: 20% Doctor Included - Exponential Medicine - YouTube.https://www.youtube.com/watch?v=tBcMxiTF2pM

12. EHR Interoperability: Why Is It So Difficult? - Continuum. 2021. https://www.carecloud.com/continuum/why-is-ehr-interoperability-so-difficult/

13. 4 Reasons Why EHR Interoperability is a Mess (and How to Fix It) Lyniate.https://lyniate.com/blog/reasons-ehr-interoperability-is-a-mess-and-how-to-fix-it/

14. Health informatics — Electronic health record — Definition, scope and context. https://www.iso.org/obp/ui/#iso:std:iso:tr:20514:ed-1:v1:en

15. Boonstra A, Versluis A, Vos JFJ. Implementing electronic health records in hospitals: A systematic literature review. BMC Health Serv Res. 2014;14(1):370. doi:10.1186/1472-6963-14-370

16. Lei J, Sockolow P, Guan P, Meng Q, Zhang J. A comparison of electronic health records at two major Peking University Hospitals in China to United States meaningful use objectives. BMC Med Inform Decis Mak. 2013;13(1). doi:10.1186/1472-6947-13-96

17. Nguyen LLT, Bellucci E, Nguyen LLT. Electronic health records implementation: An evaluation of information system impact and contingency factors. Int J Med Inform. 2014;83(11):779-796. doi:10.1016/j.ijmedinf.2014.06.011

18. Shu T, Liu H, Goss FR, et al. EHR adoption across China's tertiary hospitals: A cross-sectional observational study. Int J Med Inform. 2014;83(2):113-121. doi:10.1016/j.ijmedinf.2013.08.008

19. Robertson A, Cresswell K, Takian A, et al. Implementation and adoption of nationwide electronic health records in secondary care in England: Qualitative analysis of interim results from a prospective national evaluation. BMJ. 2010;341(7778):872. doi:10.1136/bmj.c4564

20. Poissant L, Pereira J, Tamblyn R, Kawasumi Y. The impact of electronic health records on time efficiency of physicians and nurses: A systematic review. J Am Med Informatics Assoc. 2005;12(5):505-516. doi:10.1197/jamia.M1700

21. Wachter RM. Making IT Work: Harnessing the Power of Health Information Technology to Improve Care in England.

22. Bossen C, Groth Jensen L, Witt Udsen F, Jensen LG, Udsen FW. Evaluation of a comprehensive EHR based on the DeLone and McLean model for IS success: Approach, results, and success factors. Int J Med Inform. 2013;82(10):940-953. doi:10.1016/j.ijmedinf.2013.05.010

23. Cowie MR, Blomster JI, Curtis LH, et al. Electronic health records to facilitate clinical research. Clin Res Cardiol. 2017;106(1). doi:10.1007/s00392-016-1025-6

24. Lee LM. Ethics and subsequent use of electronic health record data. J Biomed Inform. 2017;71:143-146. doi:10.1016/j.jbi.2017.05.022

25. Kelly JT, Campbell KL, Gong E, Scuffham P. The Internet of Things: Impact and Implications for HealthCare Delivery. J Med Internet Res. 2020;22(11):20135. doi:10.2196/20135

26. Greenhalgh T, Potts H, Wong G, Bark P et al. Paradoxes in Electronic Patient Record Research: A Systematic Literature Review Using the Meta-Narrative Method.; 2009.

27. Atasoy H, Greenwood BN, McCullough JS. The Digitization of Patient Care: A Review of the Effects of Electronic Health Records on HealthCare Quality and Utilization. Annu Rev Public Health. 2019;40(1):487-500. doi:10.1146/annurev-publhealth-040218-044206

28. Baumann LA, Baker J, Elshaug AG. The impact of electronic health record systems on clinical documentation times: A systematic review. Health Policy (New York). 2018;122(8):827-836. doi:10.1016/j.healthpol.2018.05.014

29. Kahn MG;, Callahan TJ;, Barnard J;, et al. A Harmonized Data Quality Assessment Terminology and Framework for the Secondary Use of Electronic Health Record Data. eGEMs (Generating Evid Methods to Improv patient outcomes). 2016;4(1):18. doi:10.13063/2327-9214.1244

30. Hemingway H, Asselbergs FW, Danesh J, et al. Big data from electronic health records for early and late translational cardiovascular research: Challenges and potential. Eur Heart J. 2018;39(16):1481-1495. doi:10.1093/eurheartj/ehx487

31. Menachemi N, Collum TH. Benefits and drawbacks of electronic health record systems. Risk Manag Healthc Policy. 2011;4:47-55. doi:10.2147/RMHP.S12985

32. Inquest into the death of Paul Lau. https://coroners.nsw.gov.au/coroners-court/download.html/documents/findings/2018/Findings Paul Lau Final.pdf

33. Takian A, Sheikh A, Barber N. We are bitter, but we are better off: case study of the implementation of an electronic health record system into a mental health hospital in England. Published online 2012. doi:10.1186/1472-6963-12-484

34. Zandieh SO, Yoon-Flannery K, Kuperman GJ, Langsam DJ, Hyman D, Kaushal R. Challenges to EHR implementation in electronic- versus paper-based office practices. J Gen Intern Med. 2008;23(6):755-761. doi:10.1007/s11606-008-0573-5

35. Jacquemard T, Doherty CP, Fitzsimons MB. The anatomy of electronic patient record ethics: a framework to guide design, development, implementation, and use. BMC Med Ethics. 2021;22(1). doi:10.1186/s12910-021-00574-x

36. Clarke A, Adamson J, Watt I, Sheard L, Cairns P, Wright J. The impact of electronic records on patient safety: A qualitative study. BMC Med Inform Decis Mak. 2016;16(1). doi:10.1186/s12911-016-0299-y

37. Triantafillou P. Making electronic health records support quality management: A narrative review. Int J Med Inform. 2017;104:105-119. doi:10.1016/j.ijmedinf.2017.03.003

38. Menon S, Singh H, Meyer AND, Belmont E, Sittig DF. Electronic health record-related safety concerns: a cross-sectional survey. J Healthc Risk Manag. 2014;34(1):14-26. doi:10.1002/jhrm.21146

39. Ajami S, ArabChadegani R, Arab-Chadegani R. Barriers to implement Electronic Health Records (EHRs). Mater Socio Medica. 2013;25(3):213. doi:10.5455/msm.2013.25.213-215

40. Gesulga JM, Berjame A, Moquiala KS, Galido A. Barriers to Electronic Health Record System Implementation and Information Systems Resources: A Structured Review. Procedia Comput Sci. 2017;124:544-551. doi:10.1016/j.procs.2017.12.188

41. Tipping MD, Forth VE, O'Leary KJ, et al. Where did the day go? - A time-motion study of hospitalists. J Hosp Med. 2010;5(6):323-328. doi:10.1002/jhm.790

42. Ross J, Stevenson F, Lau R, Murray E. Factors that influence the implementation of e-health: A systematic review of systematic reviews (an update). Implement Sci. 2016;11(1):1-12. doi:10.1186/s13012-016-0510-7

43. McKernan J, Greene RA et al. Electronic Medical Records in Obstetric and Perinatal Care | Article | GLOWM. The Continuous Textbook of Women's Medicine Series – Obstetrics Module. Published 2021. https://www.glowm.com/article/heading/vol-3--elements-of-professional-care-and-support-before-during-and-after-pregnancy--electronic-healthmedical-records-in-obstetric-and-perinatal-care/id/412413#.YMCkVPlKiUk

44. McGuire MJ, Noronha G, Samal L, Yeh HC, Crocetti S, Kravet S. Patient safety perceptions of primary care providers after implementation of an electronic medical record system. J Gen Intern Med. 2013;28(2):184-192. doi:10.1007/s11606-012-2153-y

45. Ni K, Chu H, Zeng L, Li N, Zhao Y. Barriers and facilitators to data quality of electronic health records used for clinical research in China: A qualitative study. BMJ Open. 2019;9(7):29314. doi:10.1136/bmjopen-2019-029314

46. Gunningberg L, Fogelberg-Dahm M, Ehrenberg A. Improved quality and comprehensiveness in nursing documentation of pressure ulcers after implementing an electronic health record in hospital care. J Clin Nurs. 2009;18(11):1557-1564. doi:10.1111/j.1365-2702.2008.02647.x

47. Koh J, Ahmed M. Improving clinical documentation: introduction of electronic health records in paediatrics. BMJ Open Qual. 2021;10(1):e000918. doi:10.1136/BMJOQ-2020-000918

48. Tubaishat A. The effect of electronic health records on patient safety: A qualitative exploratory study. Informatics Heal Soc Care. 2019;44(1):79-91. doi:10.1080/17538157.2017.1398753

49. Sittig DF, Singh H. A red-flag-based approach to risk management of EHR-related safety concerns. J Healthc Risk Manag. 2013;33(2):21-26. doi:10.1002/JHRM.21123

50. Hägglund M, Scandurra I. Patients' Online access to electronic health records: Current status and experiences from the implementation in Sweden. Stud Health Technol Inform. 2017;245:723-727. doi:10.3233/978-1-61499-830-3-723

51. Hägglund M, Scandurra I, Hägglund, Maria; ScaIsabella I. A Socio-Technical Analysis of Patient Accessible Electronic Health Records. Stud Health Technol Inform. 2017;244:3-7. doi:10.3233/978-1-61499-824-2-3

52. Health Information and Quality Authority (HIQA). The need to reform Ireland's national health information system to support the delivery of health and social care services. Published online 2021.

53. Corey KM, Helmkamp J, Simons M, et al. Assessing Quality of Surgical Real-World Data from an Automated Electronic Health Record Pipeline. J Am Coll Surg. 2020;230(3):295-305.e12. doi:10.1016/j.jamcollsurg.2019.12.005

54. Chen H, Hailey D, Wang N, Yu P. A review of data quality assessment methods for public health information systems. Int J Environ Res Public Health. 2014;11(5):5170-5207. doi:10.3390/ijerph110505170

55. Henley-Smith S, Boyle D, Gray K. Improving a Secondary Use Health Data Warehouse: Proposing a Multi-Level Data Quality Framework. eGEMs (Generating Evid Methods to Improv patient outcomes). 2019;7(1):38. doi:10.5334/egems.298

56. Com I. Module 1 Framework and Metrics DATA QUALITY REVIEW.; 2017.. http://apps.who.int/bookorders.

57. Kahn MG, Callahan TJ, Barnard J, et al. A Harmonized Data Quality Assessment Terminology and Framework for the Secondary Use of Electronic Health Record Data. eGEMs (Generating Evid Methods to Improv patient outcomes). 2016;4(1):18. doi:10.13063/2327-9214.1244

58. Weiskopf NG, Hripcsak G, Swaminathan S, Weng C. Defining and measuring completeness of electronic health records for secondary use. J Biomed Inform. 2013;46(5):830-836. doi:10.1016/j.jbi.2013.06.010

59. Scheid LM, Brown • L Steven, Clark • Christopher, Charles •, Rosenfeld R. Data electronically extracted from the electronic health record require validation. J Perinatol. 2019;39:468-474. doi:10.1038/s41372-018-0311-8

60. Fowles JB, Weiner JP. Electronic Health Records and the Reliability and Validity of Quality Measures: A Review of the Literature. Med Care Res Rev. 2010;67(5):503-527. doi:10.1177/1077558709359007

61. Faulconer E, de Lusignan S, An eight-step method for assessing diagnostic data quality in practice: chronic obstructive pulmonary disease as an exemplar | Faulconer | Journal of Innovation in Health Informatics. Informatics Prim Care Confernece Pap. Published online 2004. https://hijournal.bcs.org/index.php/jhi/article/view/132/159

62. Charnock V. Dissertations into Practice Electronic healthcare records and data quality. Published online 2019. doi:10.1111/hir.12249

63. Johnson M, Jefferies D, Nicholls D. Developing a minimum data set for electronic nursing handover. J Clin Nurs. 2012;21(3-4):331-343. doi:10.1111/j.1365-2702.2011.03891.x

64. Lee K, Weiskopf N, Pathak J. A Framework for Data Quality Assessment in Clinical Research Datasets. AMIA . Annu Symp proceedings AMIA Symp. 2017;2017:1080-1089. /pmc/articles/PMC5977591/?report=abstract

65. Makam AN, Lanham HJ, Batchelor K, et al. Use and satisfaction with key functions of a common commercial electronic health record: A survey of primary care providers. BMC Med Inform Decis Mak. 2013;13(1). doi:10.1186/1472-6947-13-86

66. Kohn L, Corrigan J, Donaldson M,(eds) To Err Is Human: Building a Safer Health System. Institute of Medicine (US) Committee on Quality of HealthCare in America; 2000 by the National Academy of Sciences.

67. Weiskopf NG, Bakken S, Hripcsak G, Weng C. A Data Quality Assessment Guideline for Electronic Health Record Data Reuse. eGEMs (Generating Evid Methods to Improv patient outcomes). 2017;5(1):14. doi:10.5334/egems.218

68. Health Information and Quality Authority. Guidance on a Data Quality Framework for Health and Social Care Health Information and Quality Authority.; 2018.. https://www.hiqa.ie/sites/default/files/2018-10/Guidance-for-a-data-quality-framework.pdf

69. The Book of the Rotunda Hospital : an illustrated history of the Dublin Lying-in Hospital from its foundation in 1745 to the present time : Kirkpatrick, T. Percy C. (Thomas Percy Claude), b. 1869 : Free Download, Borrow, and Streaming : Internet Archive. https://archive.org/details/bookofrotundahos00kirk/page/12/mode/2up

70. Ireland South Women & Infants Directorate Management Structures Executive Management Committee Communication and Collaboration Our Maternity Units Obstetric Report Gynaecology Report Staff.

71. Frøen JF, Myhre SL, Frost MJ, et al. eRegistries: Electronic registries for maternal and child health. Published online 2016. doi:10.1186/s12884-016-0801-7

72. Campanella P, Lovato E, Marone C, et al. The impact of electronic health records on healthcare quality: A systematic review and meta-analysis. Eur J Public Health. 2016;26(1):60-64. doi:10.1093/eurpub/ckv122

73. Roth CP, Lim YW, Pevnick JM, Asch SM, McGlynn EA. The challenge of measuring quality of care from the electronic health record. Am J Med Qual. 2009;24(5):385-394. doi:10.1177/1062860609336627

74. EMR vs EHR: What's the Difference Between EMR and EHR? https://www.usfhealthonline.com/resources/health-informatics/ehr-vs-emr/

75. Mahoney - The History of Computing in the History of Technology. http://www.princeton.edu/~hos/Mahoney/articles/hcht/hcht.html

76. Balestra ML. Electronic Health Records: Patient Care and Ethical and Legal Implications for Nurse Practitioners. J Nurse Pract. 2017;13(2):105-111. doi:10.1016/j.nurpra.2016.09.010

77. Burnel P. The introduction of electronic medical records in France: More progress during the second attempt. Health Policy (New York). 2018;122(9):937-940. doi:10.1016/j.healthpol.2018.07.022

78. Evans RS. Electronic Health Records: Then, Now, and in the Future. Yearb Med Inform. Published online 2016:S48-S61. doi:10.15265/IYS-2016-s006

79. Research AM. Electronic Health Records (EHR) Market by Product (Cloud-Based Software and Server-Based/On-Premise Software), Type (Inpatient EHR and Ambulatory EHR), Application (Clinical Application, Administrative Application, Reporting in Healthcare Sys. https://www.marketresearch.com/Allied-Market-Research-v4029/Electronic-Health-Records-EHR-Product-11416547/

80. Digital in 2018: World's internet users pass the 4 billion mark - We Are Social USA. https://wearesocial.com/us/blog/2018/01/global-digital-report-2018./

81. Ross MK, Wei W, Ohno-Machado L. "Big data" and the electronic health record. Yearb Med Inform. 2014;9:97-104. doi:10.15265/IY-2014-0003

82. Health Service Executive D of H. EHealth Strategy for Ireland.; 2013.

83. Stone CP. A Glimpse at EHR Implementation Around the World: The Lessons the US Can Learn. Inst e-Health Policy/HIMSS Found. 2014;(May):1-12. http://www.e-healthpolicy.org/docs/A_Glimpse_at_EHR_Implementation_Around_the_World1_ChrisStone.pdf

84. Doyle-Lindrud S, Editor Susan Doyle-Lindrud D-A. The Evolution of the Electronic Health Record. Clin J Oncol Nurs. 2015;19(2):153-154. doi:10.1188/15.CJON.153-154

85. WHO EMRO | eHealth | Health topics. http://www.emro.who.int/health-topics/ehealth/

86. Maternal & Newborn Clinical Management System (MN-CMS) - eHealth Ireland. https://www.ehealthireland.ie/mn-cms/

87. National Project Team MN-CMS, Maternal and Neonatal Clinical Management System Phase One Closure Report.

88. Wiljer D, Urowitz S, Apatu E, et al. Patient Accessible Electronic Health Records: Exploring Recommendations for Successful Implementation Strategies. J Med Internet Res. 2008;10(4). doi:10.2196/JMIR.1061

89. Stanford medicine. White Paper: The Future of Electronic Health Records. 2018;(September). http://med.stanford.edu/content/dam/sm/ehr/documents/SM-EHR-White-Papers_v12.pdf

90. Grimson Jane WG, Hasselbring Wilhelm. The SI Challenge in Health Care. Communications of the ACM. Published 2000. https://dl.acm.org/doi/pdf/10.1145/336460.336474

91. Hägglund, Maria; ScaIsabella I. A Socio-Technical Analysis of Patient Accessible Electronic Health Records - PubMed. Student Health Technology Information. Published 2017. https://pubmed.ncbi.nlm.nih.gov/29039366/

92. Liu J, Luo L, Zhang R, Huang T. Patient satisfaction with electronic medical/health record: A systematic review. Scand J Caring Sci. 2013;27(4):785-791. doi:10.1111/scs.12015

93. Bikker AP, Fitzpatrick B, Murphy D, Mercer SW. Measuring empathic, person-centred communication in primary care nurses: validity and reliability of the Consultation and Relational Empathy (CARE) Measure. BMC Fam Pract. 2015;16(1):1-9. doi:10.1186/s12875-015-0374-y

94. Hochman M. Electronic Health Records: a "Quadruple Win," a "Quadruple Failure," or Simply Time for a Reboot? J Gen Intern Med. 2018;33(4):397-399. doi:10.1007/s11606-018-4337-6

95. Street RL, Liu L, Farber NJ, et al. Keystrokes, Mouse Clicks, and Gazing at the Computer: How Physician Interaction with the EHR Affects Patient Participation. J Gen Intern Med. 2017;33(4):423-431. doi:10.1007/s11606-017-4228-2

96. Black AD, Car J, Pagliari C, et al. The impact of ehealth on the quality and safety of health care: A systematic overview. PLoS Med. 2011;8(1):1-16. doi:10.1371/journal.pmed.1000387

97. Jilka SR, Callahan R, Sevdalis N, Mayer EK, Darzi A. "Nothing about me without me": An interpretative review of patient accessible electronic health records. J Med Internet Res. 2015;17(6):e161. doi:10.2196/jmir.4446

98. Crosta Ahlforn K, Bojner Horwitz E, Osika W. A Swedish version of the Consultation and Relational Empathy (CARE) measure. Scand J Prim Health Care. 2017;35(3):286-292. doi:10.1080/02813432.2017.1358853

99. Lee JL, Matthias MS, Menachemi N, Frankel RM, Weiner M. A critical appraisal of guidelines for electronic communication between patients and clinicians: The need to modernize current recommendations. J Am Med Informatics Assoc. 2018;25(4):413-418. doi:10.1093/jamia/ocx089

100. Street RL, Liu L, Farber NJ, et al. Keystrokes, Mouse Clicks, and Gazing at the Computer: How Physician Interaction with the EHR Affects Patient Participation. J Gen Intern Med. 2018;33(4):423-428. doi:10.1007/s11606-017-4228-2

101. De Lusignan S, Mold F, Sheikh A, et al. Patients' online access to their electronic health records and linked online services: A systematic interpretative review. BMJ Open. 2014;4(9):1-11. doi:10.1136/bmjopen-2014-006021

102. Boquiren VM, Hack TF, Beaver K, Williamson S. What do measures of patient satisfaction with the doctor tell us? Patient Educ Couns. 2015;98(12):1465-1473. doi:10.1016/j.pec.2015.05.020

103. Horn ME, Reinke EK, Mather RC, O'Donnell JD, George SZ. Electronic health record–integrated approach for collection of patient-reported outcome measures: a retrospective evaluation. BMC Health Serv Res. 2021;21(1):1-11. doi:10.1186/S12913-021-06626-7/TABLES/5

104. Liu W, Walsh T. The impact of implementation of a clinically integrated problem-based neonatal electronic health record on documentation metrics, provider satisfaction, and hospital reimbursement: A quality improvement project. J Med Internet Res. 2018;20(6). doi:10.2196/medinform.9776

105. Zhao JY, Kessler EG, Guo WA. Interprofessional Communication Goes Up When the Electronic Health Record Goes Down. J Surg Educ. 2019;76(2):512-518. doi:10.1016/j.jsurg.2018.08.024

106. Palabindala V, Pamarthy A, Jonnalagadda NR. Adoption of electronic health records and barriers. J Community Hosp Intern Med Perspect. 2016;6(5):32643. doi:10.3402/jchimp.v6.32643

107. Aguirre RR, Suarez O, Fuentes M, Sanchez-Gonzalez MA. Electronic Health Record Implementation: A Review of Resources and Tools. Cureus. 2019;11(9). doi:10.7759/cureus.5649

108. Organisation HSE– HRD–, Design D and. People's Needs Defining Change – Health Services Change Guide.; 2018. www.hse.ie/changeguide

109. Bossen C, Jensen LG, Udsen FW. Evaluation of a comprehensive EHR based on the DeLone and McLean model for IS success: Approach, results, and success factors. Int J Med Inform. 2013;82(10):940-953. doi:10.1016/j.ijmedinf.2013.05.010

110. Delone WH, Mclean ER. The DeLone and McLean Model of Information Systems Success: A Ten-Year Update. Vol 19.; 2003.

111. Adler KG, Edsall RL. The Survey Takes Minutes, Your Response Will Help Hundreds of Colleagues, and You Just Might Win an IPad. FPM Survey of User Satisfaction With EHR Systems. Vol 19.; 2012. www.aafp.org/fpm.

112. Edsall RL, Adler KG. Where Else Can You Get EHR Advice from a Few Thousand Colleagues? The 2012 EHR User Satisfaction Survey: RESPONSES FROM 3,088 FAMILY PHYSICIANS. Vol 19.; 2012. www.aafp.org/fpm.

113. Whittaker AA, Aufdenkamp M, Tinley S. Barriers and facilitators to electronic documentation in a rural hospital. J Nurs Scholarsh. 2009;41(3):293-300. doi:10.1111/j.1547-5069.2009.01278.x

114. Mehrdad Farzandipour, Hashem Mohamadian, Hossein Akbari, Samira Safari and MSJ. Self-Assessment of Nursing Informatics Competencies in Hospitals | HIMSS. Online Journal of Nursing Informatics. Published 2020. https://www.himss.org/resources/self-assessment-nursing-informatics-competencies-hospitals

115. Asaro P V., Boxerman SB. Effects of Computerized Provider Order Entry and Nursing Documentation on Workflow. Acad Emerg Med. 2008;15(10):908-915. doi:10.1111/j.1553-2712.2008.00235.x

116. Banner L, Olney CM. Automated clinical documentation: Does it allow nurses more time for patient care. CIN - Comput Informatics Nurs. 2009;27(2):75-81. doi:10.1097/NCN.0b013e318197287d

117. Pugh CM. Electronic health records, physician workflows and system change: defining a pathway to better healthcare. doi:10.21037/atm.2019.01.83

118. Mccrorie C, Benn J, Johnson OA, Scantlebury A. Staff expectations for the implementation of an electronic health record system: a qualitative study using normalisation process theory. BMC Med Inform Decis Mak. Published online 2019. doi:10.1186/s12911-019-0952-3

119. Wiebe N, Otero Varela L, Niven DJ, Ronksley PE, Iragorri N, Quan H. Evaluation of interventions to improve inpatient hospital documentation within electronic health records: a systematic review. J Am Med Informatics Assoc. 2019;26(11):1389-1400. doi:10.1093/jamia/ocz081

120. Thiru K, de Lusignan S, Sullivan F, Brew S, Cooper A. Three steps to data quality. Inform Prim Care. 2003;11(2):95-102. doi:10.14236/jhi.v11i2.559

121. Houston ML, Yu AP, Martin DA, Probst DY. Defining and Developing a Generic Framework for Monitoring Data Quality in Clinical Research. AMIA Annu Symp Proc. 2018;2018:1300-1309.

122. Green L, Knight M, Seeney F, et al. The haematological features and transfusion management of women who required massive transfusion for major obstetric haemorrhage in the UK: a population based study. Br J Haematol. 2016;172(4):616-624. doi:10.1111/bjh.13864

123. Flood M, McDonald SJ, Pollock W, Cullinane F, Davey M. Incidence, trends and severity of primary postpartum haemorrhage in Australia: A population-based study using Victorian Perinatal Data Collection data for 764 244 births. Aust New Zeal J Obstet Gynaecol. 2019;59(2):228-234. doi:10.1111/ajo.12826

124. Corcoran P, Manning E, Meaney S, Greene RA, Centre NPE. Severe Maternal Morbidity in Ireland Annual Report 2012-2013. National Perinatal Epidemiology Centre; 2015.

125. Tan AC, Armstrong E, Close J, Harris IA. Data quality audit of a clinical quality registry: a generic framework and case study of the Australian and New Zealand Hip Fracture Registry. BMJ Open Qual. 2019;8(3):e000490. doi:10.1136/bmjoq-2018-000490

126. Health Service Executive. National Review of Clinical Audit.; 2019.

127. Centre NPE. Severe Maternal Morbidity in Ireland. Lay Summary 2018. Published 2019.https://www.ucc.ie/en/media/research/nationalperinatalepidemiologycentre/NPECSMM2018LaySummaryFinalupdated.pdf

128. O'Sullivan J, Mansfield R, Talbot R, et al. Major obstetric haemorrhage of 2000 ml or greater: a clinical audit. J Obstet Gynaecol (Lahore). 2018;38(8):1065-1072. doi:10.1080/01443615.2018.1449820

129. Paton JY, Ranmal R, Dudley J. Clinical audit: Still an important tool for improving healthcare. Arch Dis Child Educ Pract Ed. 2015;100(2):83-88. doi:10.1136/archdischild-2013-305194

130. Brace V, Kernaghan D, Penney G. Learning from adverse clinical outcomes: Major obstetric haemorrhage in Scotland, 2003-05. BJOG An Int J Obstet Gynaecol. 2007;114(11):1388-1396. doi:10.1111/j.1471-0528.2007.01533.x

131. Greene RA, McKernan J, Manning E, et al. Major obstetric haemorrhage: Incidence, management and quality of care in Irish maternity units. Eur J Obstet Gynecol Reprod Biol. 2021;257:114-120. doi:10.1016/j.ejogrb.2020.12.021

132. Institute of Obstetricians Gynaecologists Gynaecologists, Royal College of Physicians of Ireland, Executive HS, And I of O and GRC of P of I, Executive D of S and CPHS. Clinical Practice Guideline. Prevention and Management of Primary Postpartum Haemorrhage.; 2014.

133. Castor EDC. Electronic Data Capture. https://www.castoredc.com/

134. David RJ. The quality and completeness of birthweight and gestational age data in computerized birth files. Am J Public Health. Published online 1980. doi:10.2105/AJPH.70.9.964

135. Xiao Y, Bochner AF, Makunike B, et al. Challenges in data quality: The influence of data quality assessments on data availability and completeness in a voluntary medical male circumcision programme in Zimbabwe. BMJ Open. Published online 2017. doi:10.1136/bmjopen-2016-013562

136. LUCKE TW, HOLE DJ, MACKIE RM. An audit of the completeness of non-melanoma skin cancer registration in Greater Glasgow. Br J Dermatol. Published online 1997. doi:10.1046/j.1365-2133.1997.19482048.x

137. Tang PC, Ralston M, Arrigotti MF, Qureshi L, Graham J. Comparison of Methodologies for Calculating Quality Measures Based on Administrative Data versus Clinical Data from an Electronic Health Record System: Implications for Performance Measures. J Am Med Informatics Assoc. 2007;14(1):10-15. doi:10.1197/jamia.M2198

138. Ivers N, Jamtvedt G, Flottorp S, et al. Audit and feedback: Effects on professional practice and healthcare outcomes. Cochrane Database Syst Rev. 2012;2012(6). doi:10.1002/14651858.CD000259.pub3

139. Weng C. Clinical Data Quality: A Data Life Cycle Perspective. Vol 4. NIH Public Access; 2020:6. doi:10.1080/24709360.2019.1572344

140. Rigby M, Georgiou A, Hyppönen H, et al. Patient Portals as a Means of Information and Communication Technology Support to Patient-Centric Care Coordination – the Missing Evidence and the Challenges of Evaluation: A joint contribution of IMIA WG EVAL and EFMI WG EVAL. Yearb Med Inform. 2015;10(1):148. doi:10.15265/IY-2015-007

141. Weiskopf NG, Weng C. Methods and dimensions of electronic health record data quality assessment: Enabling reuse for clinical research. J Am Med Informatics Assoc. 2013;20(1):144-151. doi:10.1136/AMIAJNL-2011-000681

142. EHealth Ireland. Maternal & Newborn Clinical Management System. https://www.ehealthireland.ie/strategic-programmes/mncms/

143. Sheehan O et al. Lessons learned from the introduction of a single Electronic Health Record for maternity units in OS. Press .

144. Orfanidis L, Bamidis PD, Eaglestone B. Data quality issues in electronic health records: an adaptation framework for the Greek health system Leonidas. Health Informatics J. 2004;10(1):23-36. doi:10.1177/146045804040665

145. Dziadkowiec O, Callahan T, Ozkaynak M, Reeder B, Welton J. Using a Data Quality Framework to Clean Data Extracted from the Electronic Health Record: A Case Study. eGEMs (Generating Evid Methods to Improv patient outcomes). 2016;4(1):11. doi:10.13063/2327-9214.1201

146. Reimer AP, Milinovich A, Madigan EA. Data quality assessment framework to assess electronic medical record data for use in research. Int J Med Inform. 2016;90:40-47. doi:10.1016/j.ijmedinf.2016.03.006

147. Abernethy AP, Gippetti J, Parulkar R, Revol C. Use of electronic health record data for quality reporting. J Oncol Pract. 2017;13(8):530-534. doi:10.1200/JOP.2017.024224

148. General Data Protection Regulation (GDPR) – Official Legal Text. 2021. https://gdpr-info.eu/

149. Dziadkowiec O, Callahan T, Ozkaynak M, Reeder B, Welton J. Using a Data Quality Framework to Clean Data Extracted from the Electronic Health Record: A Case Study. eGEMs. 2016;4(1):11. doi:10.13063/2327-9214.1201

150. Agency. NPS. Safe Handover: Safe Patients Guidance on Clinical Handover for Clinicians and Managers.; 2004. https://www.rcpch.ac.uk/sites/default/files/2018-02/bma_handover_college_tutors.pdf

151. Ahmed J, Mehmood S, Rehman S, Ilyas C, Khan LUR. Impact of a structured template and staff training on compliance and quality of clinical handover. Int J Surg. 2012;10(9):571-574. doi:10.1016/j.ijsu.2012.09.001

152. Milesky JL, Baptiste DL, Shelton BK. An observational study of patient handover communications among nurses on an oncology critical care unit. Contemp Nurse. 2018;54(1):77-87. doi:10.1080/10376178.2017.1416306

153. Jorm CM, White S, Kaneen T. Clinical handover : critical communications. 2009;190(11):12-13.

154. Kruse CS, Stein A, Thomas H, Kaur H. The use of Electronic Health Records to Support Population Health: A Systematic Review of the Literature. J Med Syst. 2018;42(11). doi:10.1007/s10916-018-1075-6

155. Matic J, Davidson PM, Salamonson Y. Review: Bringing patient safety to the forefront through structured computerisation during clinical handover. J Clin Nurs. 2011;20(1-2):184-189. doi:10.1111/j.1365-2702.2010.03242.x

156. Horwitz LI, Schuster KM, Thung SF, et al. An institution-wide handoff task force to standardise and improve physician handoffs. BMJ Qual Saf. 2021;21:863–871. doi:10.1136/bmjqs-2011-000658

157. Fealy G, et al, Clinical handover practices in maternity services in Ireland_ A qualitative descriptive study | Elsevier Enhanced Reader. Midwifery. Published 2016.https://reader.elsevier.com/reader/sd/pii/S0266613816300390?token=FF4E01D3F83265559DF9A171DD6FDA470B0A872B2163C285B4DD88EAFCE7EE6E39FC1C1C833ACF7F755BF9FBB2656F50&originRegion=eu-west-1&originCreation=20210616171353

158. National Clinical Effectiveness Committee. Communication (Clinical Handover) in Maternity Services.; 2014.. www.health.gov.ie/patient-safety/ncec.

159. McKernan J, Corcoran P, Greene R. Examining the implications of the implementation of an Electronic Health Record on staff: lessons learned. Press. Published online 2021.

160. Curry LA, Nembhard IM, Bradley EH. Qualitative and mixed methods provide unique contributions to outcomes research. Circulation. 2009;119(10):1442-1452. doi:10.1161/CIRCULATIONAHA.107.742775

161. Tavory I, Timmermans S. Two cases of ethnography: Grounded theory and the extended case method. 2009;10(3):243-263. doi:10.1177/1466138109339042

162. Sangasubana N. How to Conduct Ethnographic Research. Qual Rep. 2011;16:567-573. http://www.nova.edu/ssss/QR/QR16-2/sangasubanat.pdf

163. Smith D, Morris A, Janke J. Nursing satisfaction and attitudes with computerized software implementation: A quasi-experimental study. CIN - Comput Informatics Nurs. 2011;29(4):245-250. doi:10.1097/NCN.0b013e3181f9dcfa

164. Shahid S, Thomas S. Situation, Background, Assessment, Recommendation (SBAR) Communication Tool for Handoff in HealthCare – A Narrative Review. Saf Heal 2018 41. 2018;4(1):1-9. doi:10.1186/S40886-018-0073-1

165. Anderson J, Shroff D, Curtis A, et al. The Veterans Affairs Shift Change Physician-to-Physician Handoff Project. Jt Comm J Qual Patient Saf. 2010;36(2):AP1. doi:10.1016/S1553-7250(10)36012-0

166. Kochendorfer KM, Morris LE, Kruse RL, Mehr DR. Attending and Resident Physician Perceptions of an EMR-generated Rounding Report for Adult Inpatient Services. 2010;42(5):343.

167. BW P, K H, B M. Identification of patient information corruption in the intensive care unit: using a scoring tool to direct quality improvements in handover. Crit Care Med. 2009;37(11):2905-2912. doi:10.1097/CCM.0B013E3181A96267

168. Health D of. Communication (Clinical Handover) in Acute and Children's Hospital Services National Clinical Guideline No. 11. 2015;(11):1-248. doi:ISSN 2009-6259

169. Thomas L, Donohue-Porter P. Blending evidence and innovation: Improving intershift handoffs in a multihospital setting. J Nurs Care Qual. 2012;27(2):116-124. doi:10.1097/NCQ.0B013E318241CB3B

170. Lang A, Simmonds M, Pinchin J, et al. The Impact of an Electronic Patient Bedside Observation and Handover System on Clinical Practice: Mixed-Methods Evaluation. JMIR Med Informatics. 2019;7(1). doi:10.2196/11678

171. Giske T, Melås SN, Einarsen KA. The art of oral handovers: A participant observational study by undergraduate students in a hospital setting. J Clin Nurs. 2018;27(5-6):e767-e775. doi:10.1111/JOCN.14177/FORMAT/PDF

172. System of Health Accounts 2019 - CSO - Central Statistics Office. https://www.cso.ie/en/releasesandpublications/ep/p-sha/systemofhealthaccounts2019/

173. Global spending on health: Weathering the storm. Geneva: World Health Organization; Published 2020. https://www.who.int/publications/i/item/9789240017788

174. Blumenthal D, Fowler EJ, Abrams M, Collins SR. Covid-19 — Implications for the HealthCare System. N Engl J Med. 2020;383(15):1483-1488. doi:10.1056/NEJMSB2021088/SUPPL_FILE/NEJMSB2021088_DISCLOSURES.PDF

175. Department of Health, Department of Health Statement of Strategy 2021-2023.; 2021.

176. Strategic Business Case National Electronic Health Record Strategic Business Case. Published online 2016.

177. Blayney DW. Transforming data from information to quality improvement: A panel discussion with electronic health record vendors. J Oncol Pract. 2015;11(3):174-175. doi:10.1200/JOP.2015.004267

178. Sláinte Building S, Fearr N, Health B. Factors for Success in Electronic Health Record Implementation: Literature Review and Key Considerations.

179. Tsai CH, Eghdam A, Davoody N, Wright G, Flowerday S, Koch S. Effects of Electronic Health Record Implementation and Barriers to Adoption and Use: A Scoping Review and Qualitative Analysis of the Content. Life. 2020;10(12):1-27. /pmc/articles/PMC7761950/

180. Reisman M. EHRs: The Challenge of Making Electronic Data Usable and Interoperable. Pharm Ther. 2017;42(9):572. /pmc/articles/PMC5565131/

181. Li E, Clarke J, Neves AL, Ashrafian H, Darzi A. Electronic Health Records, Interoperability and Patient Safety in Health Systems of High-income Countries: A Systematic Review Protocol. BMJ Open. 2021;11(7):e044941. doi:10.1136/BMJOPEN-2020-044941

182. Berndt M, Fischer MR. The role of electronic health records in clinical reasoning. Ann N Y Acad Sci. 2018;1434(1):109-114. doi:10.1111/NYAS.13849

183. Health Information and Quality Authority. National Public Engagement on Health Information Findings from the. Published online 2020.

184. McKernan J, Corcoran P, Greene R. Patient experience of the Electronic Health Record (EHR) in a maternity unit in Ireland.

185. Digital Transformation in Healthcare in 2021: 7 Key Trends | DAP. https://www.digitalauthority.me/resources/state-of-digital-transformation-healthcare/

186. Almathami HKY, Than Win K, Vlahu-Gjorgievska E. Barriers and Facilitators That Influence Telemedicine-Based, Real-Time, Online Consultation at Patients' Homes: Systematic Literature Review. J Med Internet Res. 2020;22(2). doi:10.2196/16407

187. Nilsen P, Seing I, Ericsson C, Birken SA, Schildmeijer K. Characteristics of successful changes in healthcare organizations: an interview study with physicians, registered nurses and assistant nurses. doi:10.1186/s12913-020-4999-8

188. Akhu-Zaheya L, Al-Maaitah R, Bany Hani S. Quality of nursing documentation: Paper-based health records versus electronic-based health records. J Clin Nurs. 2018;27(3-4):e578-e589. doi:10.1111/jocn.14097

189. Wang N, Yu P, Hailey D. The quality of paper-based versus electronic nursing care plan in Australian aged care homes: A documentation audit study. Int J Med Inform. 2015;84(8):561-569. doi:10.1016/j.ijmedinf.2015.04.004

190. Scantlebury A, Sheard L, Watt I, Cairns P, Wright J, Adamson J. Exploring the implementation of an electronic record into a maternity unit: a qualitative study using Normalisation Process Theory. BMC Med Inform Decis Mak. 2017;17(1):1-10. doi:10.1186/s12911-016-0406-0

191. Kelly A, Thompson JP, Tuttle D, Benesch C, Holloway RG. Public reporting of quality data for stroke: Is it measuring quality? Stroke. 2008;39(12):3367-3371. doi:10.1161/STROKEAHA.108.518738

192. Kapsner LA, Kampf MO, Seuchter SA, et al. Moving towards an EHR data quality framework: The miracum approach. In: Studies in Health Technology and Informatics. Vol 267. IOS Press; 2019:247-253. doi:10.3233/SHTI190834

193. The Importance of Data Quality in Banking and Finance. https://intelligent-ds.com/blog/the-importance-of-data-quality-in-banking-and-finance

194. Simms RA, Yelland A, Ping H, Beringer AJ, Draycott TJ, Fox R. Using data and quality monitoring to enhance maternity outcomes: A qualitative study of risk managers' perspectives. BMJ Qual Saf. 2014;23(6):457-464. doi:10.1136/bmjqs-2013-002025

195. Menachemi N, Randeree E, Burke DE, Ford EW. Planning for Hospital IT Implementation: A New Look at the Business Case. Biomed Inform Insights. 2008;1:BII.S1035. doi:10.4137/bii.s1035

196. Consultant E. Glossary and Acronyms of EMR / EHR Terminology 2019.

197. Information Technology (IT) Glossary - Essential Information Technology (IT) Terms & Definitions Gartner. https://www.gartner.com/en/information-technology/glossary

Supporting materials

Appendix I: Glossary Terms from Chapter 2

Alerts	Pop-ups or reminders. An automated warning system such a clinical alerts, preventive health maintenance, medication interactions, etc.[196]
Bandwidth	A data transmission rate; the maximum amount of information (bits/second) that can be transmitted along a channel.[196]
(CDR) Clinical Data Repository	A real-time database that consolidates data from a variety of clinical sources to present a unified view of a single patient. It is optimized to allow clinicians to retrieve data for a single patient rather than to identify a population of patients with common characteristics or to facilitate the management of a specific clinical department.[196]
CCIO	Chief Clinical Information Officer
CMIO	Chief Medical Information Officer
CPOE	Computer Provider Order Entry The most important function of CPOE is to make it easy for the provider to do the correct thing for the patient and difficult to do the wrong thing for the patient.[196]
Data Integrity	Refers to the validity of data. A condition in which data has not been altered or destroyed in an unauthorized manner.[196]
Data Mining	The process of analysing or extracting data from a database to identify patterns or relationships.[196]
Data Structure	A way to store and organize data in order to facilitate access and modifications.[196]
Database	A collection of information organized in such a way that a computer program can quickly select desired pieces of data.[196]
Digital Signature	Digital signature takes the traditional hand-written signature and creates a digital image of the signature to eliminate the need to print and sign documents.[196] Another approach

	taken is a build identifier: this is a medical licence number and name attached to a login.
Documentation	The process of recording information.[196]
eHealth	eHealth is the use of information and communication technologies (ICT) for health.[85]
Encryption	Process of converting messages or data into a form that cannot be read without decrypting or deciphering it.[196]
e-Prescribing	Prescribing medication through an automated data-entry process and transmitting the information to participating pharmacies.[196]
Information Governance	The specification of decision rights and an accountability framework to ensure appropriate behaviour in the valuation, creation, storage, use, archiving and deletion of information. It includes the processes, roles and policies, standards and metrics that ensure the effective and efficient use of information in enabling an organization to achieve its goals.[197]
Patient Portal	Allow patients and providers to communicate over the Internet in a secure environment.[196] It is the patient view of an EHR.
SNOMED CT® – Systematized Nomenclature of Medicine – Clinical Terms	SNOMED CT ® is a clinical, healthcare terminology and infrastructure. SNOMED CT ® contains over 366,170 healthcare concepts with unique meanings and formal logic-based definitions organized into hierarchies.[196]
Webinar	A lecture, presentation, workshop, or seminar that is transmitted over the Web. Short for Web-based Seminar.[196]
Workflow	The automation of a process, in whole or part, during which documents, information or tasks are passed from one participant to another for action, according to a set of procedural rules.[196]

Appendix II: Supplementary table from Chapter 3

Table 3.1: Between group summary statistics for satisfaction level

Factor	Group	Mean (SD)
Women	First time mother (n=62)	46.4 (11.4)
	Woman who already had a baby in CUMH (n=95)	46.3 (10.9)
	Woman who already had baby but not in CUMH (n=23)	47.2 (9.0)
Q16 Did you feel documentation by electronic health record altered your consultation on your visit	Yes (n=94)	49.0 (10.1)
	No (n=55)	42.1 (11.0)
	Not sure (n=27)	46.4 (10.9)
Q17 I believe the computer will help the clinic be efficient	Yes (n=40)	46.8 (11.0)
	No (n=105)	47.6 (10.6)
	Not sure (n=28)	41.4 (10.9)
Q18 I believe the computer will help ensure the quality of my care	Yes (n=148)	46.7 (11.2)
	No (n=4)	44.0 (6.5)
	Not sure (n=25)	46.0 (9.9)
Q19 I believe personal information is safe in the computer	Yes (n=130)	47.1 (11.0)
	No (n=8)	44.8 (8.8)
	Not sure (n=37)	44.6 (11.0)
Q20 I have concerns about the new computer system	Yes (n=116)	47.4 (10.3)
	No (n=10)	44.6 (12.4)
	Not sure (n=50)	45.1 (11.9)
Q21 It would be helpful if more information was available regarding the new computer system	Yes (n=18)	44.5 (12.0)
	No (n=134)	47.4 (10.2)
	Not sure (n=22)	44.4 (12.8)

Note: SD=standard deviation

Appendix III: Patient Survey from Chapter 3

Maternal and Neonatal Clinical Management System (MN-CMS) Introduction: Patient Satisfaction Study

Please complete the following questions about you:

1	Is this your first pregnancy?	Yes	No
2	Have you had a baby here before; If no where	Yes	No
3	Is this your first visit to the clinic?	Yes	No
4	If this is your first visit to the clinic are you aware that the hospital now uses a new computer system (electronic health record (MN-CMS)	Yes	No
5	If no how many visits have you made to the clinic:		

Questions regarding the staff you encountered on your visit:

6	Did staff make you feel at ease… (being friendly and warm towards you, treating you with respect; not cold or abrupt)						
	Poor to Fair	Fair	Fair to Good	Good	Very Good	Excellent	Outstanding
7	Let you tell "your" story… (giving you time to fully describe; not interrupting or diverting you)						
	Poor to Fair	Fair	Fair to Good	Good	Very Good	Excellent	Outstanding
8	Did you feel they were really listening… (paying close attention to what you were saying; not looking at the notes or computer as you were talking)						
	Poor to Fair	Fair	Fair to Good	Good	Very Good	Excellent	Outstanding
9	Being interested in you as a whole person… (asking/knowing relevant details about your life, your situation; not treating you as "just a number")						
	Poor to Fair	Fair	Fair to Good	Good	Very Good	Excellent	Outstanding
10	Fully understanding your concerns… (communicating that he/she had accurately understood your concerns; not overlooking or dismissing anything)						
	Poor to Fair	Fair	Fair to Good	Good	Very Good	Excellent	Outstanding

11	Showing care and compassion… (seeming genuinely concerned, connecting with you on a human level; not being indifferent or "detached")						
	Poor to Fair	Fair	Fair to Good	Good	Very Good	Excellent	Outstanding

12	Explaining things clearly… (fully answering your questions, explaining clearly, giving you adequate information; not being vague)						
	Poor to Fair	Fair	Fair to Good	Good	Very Good	Excellent	Outstanding
13	Making a plan of action with you… (discussing the options, involving you in decisions as much as you want to be involved; not ignoring your views)						
	Poor to Fair	Fair	Fair to Good	Good	Very Good	Excellent	Outstanding
14	Overall, how would you rate your consultation with this staff today?						
	Poor to Fair	Fair	Fair to Good	Good	Very Good	Excellent	Outstanding

About the new system

15	The staff member explained his or her use of the computer to me.	☐Yes	☐No	☐Not Sure
16	Did you feel documentation by electronic health record altered your consultation on your visit?	☐Yes	☐No	☐Not Sure
17	I believe the computer will help the clinic be efficient.	☐Yes	☐No	☐Not Sure
18	I believe the computer will help ensure the quality of my care.	☐Yes	☐No	☐Not Sure
19	I believe personal information is safe in the computer.	☐Yes	☐No	☐Not Sure
20	I have concerns about the new computer system	☐Yes	☐No	☐Not Sure
21	It would be helpful if more information was available regarding the new computer system (MN-CMS) (please tick all that apply)	☐Yes	☐No	☐Not Sure
21a	By leaflet	☐Yes	☐No	☐Not Sure
21b	From staff	☐Yes	☐No	☐Not Sure
21c	From my GP	☐Yes	☐No	☐Not Sure
21d	At antenatal classes	☐Yes	☐No	☐Not Sure

22	Would you like access to your Electronic Health Record online	☐Yes	☐No	☐Not Sure
23	If yes, would you like access to your: (please tick all that apply)			
23a	Full chart	☐Yes	☐No	☐Not Sure
23b	Antenatal visits notes	☐Yes	☐No	☐Not Sure
23c	Delivery Notes	☐Yes	☐No	☐Not Sure
23d	Baby Notes	☐Yes	☐No	☐Not Sure

Comments:

Appendix IV: Staff Questionnaire from Chapter 4

Adapted from the Family Practice Management (FPM) Questionnaire of User Satisfaction with EHR Systems

Demographic Information

1. Role at the unit (please circle)

Consultant NCHD Midwife Midwifery Management

Pharmacist Allied Health Professional (e.g. physiotherapist etc.) Administration Student

Other Please specify _____

2. How long have been using the EHR? (months)

☐ 0-5 ☐ 6-11 ☐ 12 -17 ☐ 18+

3. How many hours training did you receive at first? _____

4. How many hours training since the implementation of the EHR have you received?

EHR overview

5. The training provided prepared me to perform my duties using the EHR in my unit.

☐Strongly Agree ☐Disagree

☐Agree ☐Strongly Disagree

6. I would appreciate the opportunity for additional training on the EHR.

☐Strongly Agree ☐Disagree

☐Agree ☐Strongly Disagree

7. Following the initial EHR implementation at my unit, my personal productivity has now returned to normal.

☐Strongly Agree ☐Disagree

8. Using the EHR increases the quality and accuracy of my work.

☐Strongly Agree ☐Disagree

☐Agree ☐Strongly Disagree

9. I believe I am operating at the full extent of my education using the EHR

☐Strongly Agree ☐Disagree

☐Agree ☐Strongly Disagree

10. Overall, I am happy with the EHR implementation.

☐Strongly Agree ☐Disagree

☐Agree ☐Strongly Disagree

11. Would you return to a paper-based record?

☐Yes ☐No

Please note some questions may not apply to you (please skip to the next relevant question)

EHR Usability and Usefulness

12. I feel confident navigating and documenting in the EHR while seeing patients

☐Strongly Agree ☐Disagree

☐Agree ☐Strongly Disagree

13. I am able to easily locate the appropriate template content to complete my documentation.

☐Strongly Agree ☐Disagree

14. I feel confident navigating and documenting in the EHR to complete activities not directly related to patient office visits.

☐Strongly Agree ☐Disagree

☐Agree ☐Strongly Disagree

15. I am able to effectively leverage the tasking functionality within the EHR

☐Strongly Agree ☐Disagree

☐Agree ☐Strongly Disagree

16. I understand how to electronically review and respond to my patient's ancillary and diagnostic testing results (e.g., lab and radiology reports).

☐Strongly Agree ☐Disagree

☐Agree ☐Strongly Disagree

17. All of my patient's previous testing results are stored in a manner that allows me to easily review prior results, identify trends, and determine a plan of care.

☐Strongly Agree ☐Disagree

☐Agree ☐Strongly Disagree

18. All the information I need to assess a patient's condition(s) and

determine the appropriate plan of care is available within the EHR.

☐Strongly Agree ☐Disagree

19. I understand and utilize the medication reconciliation work flow with each patient encounter

☐Strongly Agree ☐Disagree

20. I am able to quickly search for, select, and enter/update my patient's medication(s).

☐Strongly Agree ☐Disagree

☐Agree ☐Strongly Disagree

21. I am able to electronically prescribe all of my patient's medications with ease.

☐Strongly Agree ☐Disagree

☐Agree ☐Strongly Disagree

22. I find the electronic refill request for my outpatient clinics useful.

☐Strongly Agree ☐Disagree

☐Agree ☐Strongly Disagree

23. The EHR provides useful tools for disease management and/or preventive medicine (for example, diagnosis-specific prompts, alerts, and patient education materials).

☐Strongly Agree ☐Disagree

☐Agree ☐Strongly Disagree

24. I am aware of and utilize disease- and/or specialty-specific content for the majority of my documentation needs, as opposed to generic templates and free text.

☐Strongly Agree ☐Disagree

☐Agree ☐Strongly Disagree

25. The following statements describes my primary concern regarding using an EHR:

Please choose the appropriate response for each item	Agree	Disagree
Using an EHR slows me down, and I cannot see the number of patients that I would like to in a day		
Using an EHR slows me down; while I can see the number of patients that I would like to in a day, I have to spend additional time completing my documentation		

The documentation provided by the EHR is inadequate to support my requirements for a complete and comprehensive medical record that supports referrals and/or consultations		
I am not comfortable using a computer, especially in front of my patients		
Many of my clinical colleagues have difficulties utilizing the EHR and find it challenging to learn or progress.		
I find the EHR to be useful to my unit, and I have no concerns about using it		

26. List three features in the EHR that are causing frequent problems:
1) _____
2) _____
3) _____
27. List three features of the EHR that you feel improves patient care.
1) _____
2) _____
3) _____
28. Please describe your overall experience with the EHR in one word

_____

29.The following best describes my documentation patterns in the EHR while seeing patients: Please choose all that apply:

☐ I complete all of my documentation while in the exam room with the patient.

☐ I complete a portion of my documentation while in the exam room with the patient.

☐ I do not document in the EHR while in the exam room with the patient.

☐ I do not complete my documentation of patient care in the EHR (I dictate or use handwritten notes instead).

30. I primarily use the following method of data input:

☐ Point and click using EHR templates

☐ Type everything using free text.

☐ Use a combination of point and click and free-text typing

Please list any suggestions for enhancement of the EHR

_____

_____

_____

EHR Support

31. The hardware and network supporting the EHR is reliable both in terms of availability ("uptime") and speed.

☐Strongly Agree ☐Disagree

☐Agree ☐Strongly Disagree

32. I feel the device(s) used to access the EHR at the Hospital enables an efficient workflow.

☐Strongly Agree ☐Disagree

☐Agree ☐Strongly Disagree

---

33. I know who the operational leaders are within my organization who will make sure that the EHR is designed and used to improve the health of our patients, enhance the experience of our patients, and/or reduce costs

☐Strongly Agree ☐Disagree

☐Agree ☐Strongly Disagree

34. I have colleagues within my organization who I know and respect who have effectively adopted the EHR and can help me make practical changes to the way I use the system and my work flows.

☐Strongly Agree ☐Disagree

☐Agree ☐Strongly Disagree

35. I have colleagues within my organization who are technically savvy and participate in EHR design decisions.

☐Strongly Agree ☐Disagree

☐Agree ☐Strongly Disagree

36. IT Support is responsive at my organization.

☐Strongly Agree ☐Disagree

☐Agree ☐Strongly Disagree

37. My organization has the right number and types of IT resources to support me in my use of the EHR.

☐Strongly Agree ☐Disagree

☐Agree ☐Strongly Disagree

38. I can easily get help when I am having a problem using the EHR.

☐Strongly Agree ☐Disagree

☐Agree ☐Strongly Disagree

39. When I need help using the EHR, I primarily rely on: (tick all that apply)

☐ Colleagues in my clinic who are proficient with the system

☐ Designated superusers within the clinic(s).

☐ The IT department.

☐ Management/leadership.

☐ Other – please comment:

40. Medication prescribing in EHR is well organized and enhances patient safety

☐Strongly Agree ☐Disagree

☐Agree ☐Strongly Disagree

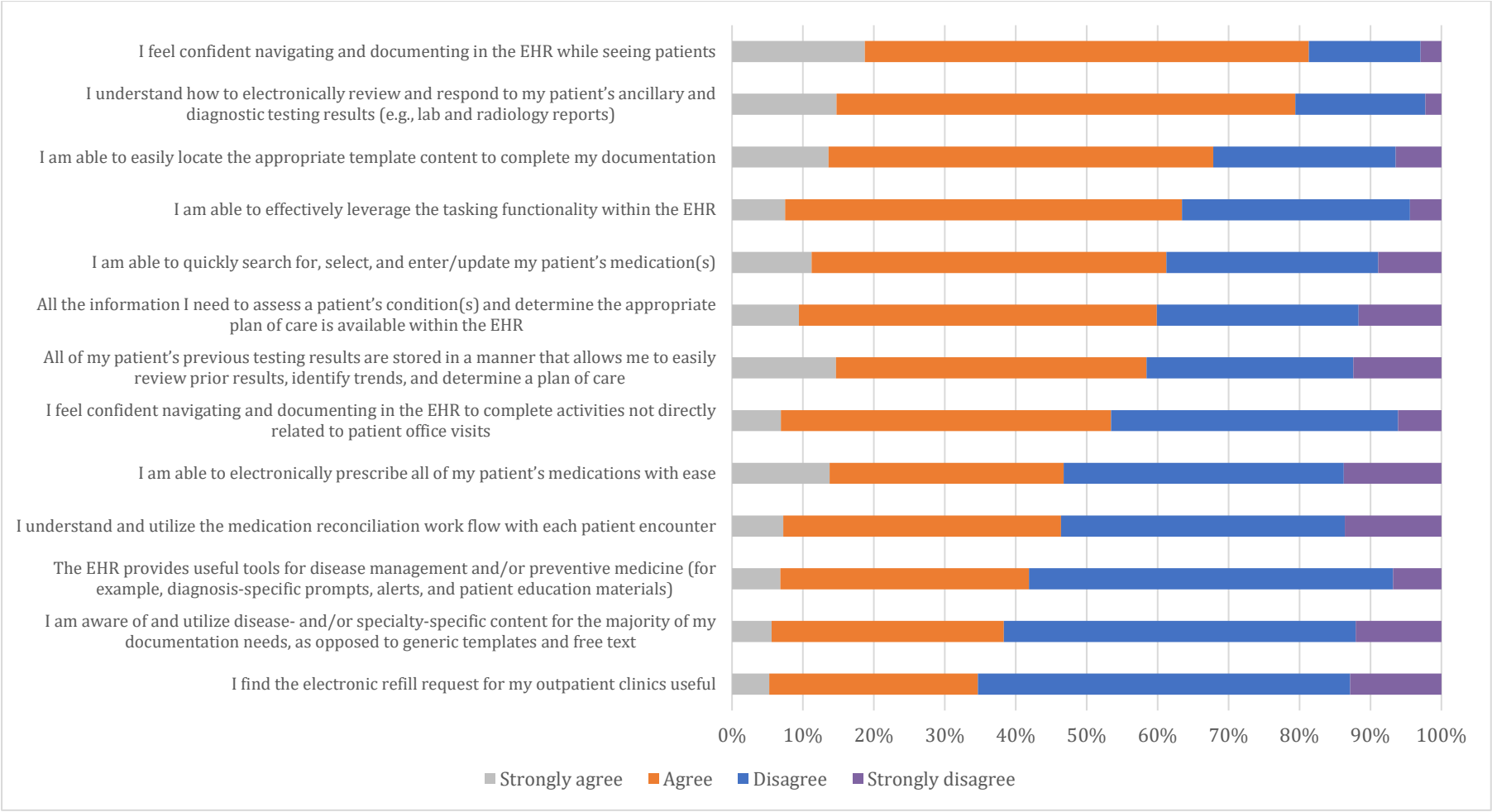
41. While documentation may take longer easy access to investigations results has saved time

☐Strongly Agree ☐Disagree

☐Agree ☐Strongly Disagree

Any other comments:

Appendix V: Supplementary figure from Chapter 4



Appendix VI: Supplementary file from Chapter 5

Supplementary. Five dimensions (no=1, partially=2 and yes=3)

Adapted from the Data assessment tool from the Guidance on a Data Quality Framework for Health and Social Care Health Information and Quality Authority

Relevance (maximum score=18)		**score**
Release and use of the data	Are regular assessments carried out to determine whether all of the data that is being collected is being used?	1
	Has a list of key users and their use of the data been compiled, including unmet user needs?	2
Value of the data	Are data users consulted to establish if the data available assists them in achieving their objectives?	3
	Are quality improvement plans in place to address required improvements in the data in order to ensure the data remains relevant to users?	3
Adaptability of the data source	Are procedures in place to gather information on the potential future needs of data users?	2
	Are data user needs prioritised as a result of consultation undertaken with data users about how the data relates to their needs?	1
	Total	12
Accuracy and reliability (maximum score=21)		
Coverage	Are details of the reference population explicitly stated in all information releases and is the coverage of the population quantified?	3
	Are significant coverage issues that may impact analysis and interpretation of data documented and made available to users?	1
	Are processes in place to identify and handle duplicate and potential duplicate records within the data?	3
Data capture and collection	Are issues with the quality of data submitted, that have the potential to impact significantly on analysis and interpretation of that data, addressed and documented for users of the data?	2
Data processing	Are data validation processes applied consistently and are the processes documented for data users?	2
Completeness and validity	Are rates of valid, invalid, missing and outlier values documented and updated routinely and reported with each data release?	1
Revisions to data	Are revisions or corrections made to the data regularly analysed to ensure effective statistical use of same?	1
	Total	13
Timeliness (maximum score=24)		
Submission timeliness	Are procedures in place to ensure the effective and timely submission of data from providers?	3
	Are agreements in place with data providers which detail planned dates for submission of data?	3
	Are follow-up procedures in place to ensure timely receipt of data, including procedures to address necessary improvements?	3
Processing timeliness	Are data processing activities regularly and systematically reviewed to improve timeliness and has an associated action plan been developed and implemented?	1
Release timeliness and punctuality	Has a data release policy and procedures document, which includes targets for timeliness, been developed, published and implemented? Does the policy describe revisions for key outputs that are subject to scheduled revisions?	1
	Do planned releases occur within a specified period of time from the end of the reference period?	3

	In the event of delays affecting a planned release, are delays and causes documented and made available to data users?	1
	Is an up-to-date release calendar publicly available?	1
	Total	16
Coherence and comparability (maximum score=21)		
Standardisation	Is data collected in line with national and international standards and classifications	3
	Are metadata clearly described and made available to data users?	1
Coherence	Are data processing activities regularly and systematically reviewed to improve timeliness and has an associated action plan been developed and implemented?	2
Release timeliness and punctuality	Is aggregated data compared with other sources of data, for example, administrative data, that provide the same or similar information on the same phenomenon? Are divergences identified and clearly explained to data users?	2
Historical comparability	Are historical changes/trends in the data documented and publicly available for data users?	3
	Are any changes in the data/trends that can potentially have a significant impact on interpretation and analysis of data, that is, changes to key elements of the data set, documented and available for data users?	3
Regional comparability	Is the impact of any identified differences in data across regions documented?	3
	Total	17
Accessibility and clarity (maximum score=12)		
Accessibility	Are data available to users in a form that facilitates proper interpretation and meaningful comparisons?	3
	Is ICT effectively used to disseminate data and information?	3
Interpretability	Are supporting documents, for example, metadata, publicly available to facilitate clarity of interpretation for data users?	2
	Does a revision policy exist which covers all data and is it available to data users?	1
	Total	9

Appendix VII: Search strategy for MOH Data quality from Chapter 5

PubMed: Date:

#	Keywords	Hits
#1	data quality [MeSH Major Topic]	1,112
#2	data quality	539,094
#3	data framework	97,670
#4	Data quality review	116,813
#5	clinical audit [MeSH Major Topic]	9,001
#6	clinical audit	32,543
#7	Major Obstetric Haemorrhage [MeSH Major Topic]	793
#8	major obstetric haemorrhage	7,774
	(#1 or #2 or #3 or #4 or #5 or #6) AND (#7 or #8)	386
	(#1 or #2 or #3 or #4 or #5 or #6) AND #7	59

Note: The following terms were not found in PubMed: review, framework.

Web of Science: Date:

#	Keywords	Hits
#1	data quality	647,316
#2	data framework	341,017
#3	Data quality review	94,540
#4	clinical audit	27,766
#5	major obstetric haemorrhage	300
	(#1 or #2 or #3 or #4)	973,756
	(#1 or #2 or #3 or #4) AND #5	24

CINALH Plus: Date:

#	Keywords	Hits
#1	data quality	20,277
#2	data framework	3,576
#3	Data quality review	1,099
#4	clinical audit	2,340
#5	major obstetric haemorrhage	74
	(#1 or #2 or #3 or #4)	25,964
	(#1 or #2 or #3 or #4) AND #5	4

Appendix VIII: Supplementary file from Chapter 6

Supplementary. Five dimensions (no=1, partially=2 and yes=3)

Adapted from the Data assessment tool from the Guidance on a Data Quality Framework for Health and Social Care Health Information and Quality Authority

Relevance (maximum score=18)		**score**
Release and use of the data	Are regular assessments carried out to determine whether all of the data that is being collected is being used?	2
	Has a list of key users and their use of the data been compiled, including unmet user needs?	3
Value of the data	Are data users consulted to establish if the data available assists them in achieving their objectives?	3
	Are quality improvement plans in place to address required improvements in the data in order to ensure the data remains relevant to users?	3
Adaptability of the data source	Are procedures in place to gather information on the potential future needs of data users?	2
	Are data user needs prioritised as a result of consultation undertaken with data users about how the data relates to their needs?	2
	Total	15
Accuracy and reliability (maximum score=21)		
Coverage	Are details of the reference population explicitly stated in all information releases and is the coverage of the population quantified?	3
	Are significant coverage issues that may impact analysis and interpretation of data documented and made available to users?	2
	Are processes in place to identify and handle duplicate and potential duplicate records within the data?	3
Data capture and collection	Are issues with the quality of data submitted, that have the potential to impact significantly on analysis and interpretation of that data, addressed and documented for users of the data?	2
Data processing	Are data validation processes applied consistently and are the processes documented for data users?	2
Completeness and validity	Are rates of valid, invalid, missing and outlier values documented and updated routinely and reported with each data release?	2
Revisions to data	Are revisions or corrections made to the data regularly analysed to ensure effective statistical use of same?	2
	Total	16
Timeliness (maximum score=24)		
Submission timeliness	Are procedures in place to ensure the effective and timely submission of data from providers?	3
	Are agreements in place with data providers which detail planned dates for submission of data?	3
	Are follow-up procedures in place to ensure timely receipt of data, including procedures to address necessary improvements?	3
Processing timeliness	Are data processing activities regularly and systematically reviewed to improve timeliness and has an associated action plan been developed and implemented?	3
Release timeliness and punctuality	Has a data release policy and procedures document, which includes targets for timeliness, been developed, published and implemented? Does the policy describe revisions for key outputs that are subject to scheduled revisions?	2
	Do planned releases occur within a specified period of time from the end of the reference period?	3
	In the event of delays affecting a planned release, are delays and causes documented and made available to data users?	3

	Is an up-to-date release calendar publicly available?	2
	Total	22
Coherence and comparability (maximum score=21)		
Standardisation	Is data collected in line with national and international standards and classifications	3
	Are metadata clearly described and made available to data users?	2
Coherence	Are data processing activities regularly and systematically reviewed to improve timeliness and has an associated action plan been developed and implemented?	3
Release timeliness and punctuality	Is aggregated data compared with other sources of data, for example, administrative data, that provide the same or similar information on the same phenomenon? Are divergences identified and clearly explained to data users?	3
Historical comparability	Are historical changes/trends in the data documented and publicly available for data users?	2
	Are any changes in the data/trends that can potentially have a significant impact on interpretation and analysis of data, that is, changes to key elements of the data set, documented and available for data users?	2
Regional comparability	Is the impact of any identified differences in data across regions documented?	3
	Total	18
Accessibility and clarity (maximum score=12)		
Accessibility	Are data available to users in a form that facilitates proper interpretation and meaningful comparisons?	3
	Is ICT effectively used to disseminate data and information?	3
Interpretability	Are supporting documents, for example, metadata, publicly available to facilitate clarity of interpretation for data users?	2
	Does a revision policy exist which covers all data and is it available to data users?	2
	Total	10

Appendix IX: Supplementary information from chapter 6

The tables outlined below captures the data completeness of each variable for each report for the years studied 2018,2019,2020. In the table we notice the improvement in the *daily delivery list* because the DQM was spending time checking this dataset. We have included administration variables for e.g., medical record number, financial number. We have also included variables that will not be captured for all patients e.g., Artificial Rupture indication (Mother), Oxytocin (Mother). In the breastfeeding report there has been an improvement in the capture of the variables *measured weight* and *feeding type at discharge.* The data completeness has improved from 73% in 2018 to 95% in 2020. In the neonatal discharge report the variables that improved over time include *last length measured* from 25% to 62%. The *newborn birth length* variable improved from 5% to 58%. The pregnancy loss report is capturing data well but not always in a systematic way we can see from the linked variables *max date of delivery, max delivery outcome, estimated EGA date, EGA* shows that work is required in this area.

Daily Delivery List

Variable	2018	2019	2020
MRN	100	100	100
Financial Number	100	100	100
Person Name- Full	100	100	100
Parity Before Delivery	100	100	100
Payer Type	100	100	100
Admit Source (Mother)	97	99	100
Pevious C/S	100	100	100
Delivery Date, Time (Mother)	100	100	100
Birth Order (Mother)	96	100	100
Neonate Outcome (Mother)	97	100	100
Pathway to Delivery (Mother)	97	100	100
Birth Weight (g) - Mother	97	100	100
EGA (Mother)	100	100	100
Mother (Delivery Category)	96	100	100
Delivery Type All (Mother)	95	100	100
Membrane Status (Mother)	94	96	98
Artificial Rupture Indication (Mother)	40	44	47
Oxytocin (Mother)	57	59	55
Delivered By (Mother)	90	97	99
Clinician (Midwife) Mother	84	86	65
Clinician (Obstetrician) Mother	45	48	36
Baby Transferred To:: (Mother)	91	98	98

Breastfeeding Report

Variable	2018	2019	2020
Baby MRN	100	100	100
Financial Number	100	100	100
Baby Name	100	100	100
Discharge Location	100	100	100
Discharge To Location	100	100	100
Neonate Outcome	97	99	99
Delivery Type - All	93	97	97
Discharge Month (Infant)	100	100	100
Birth Month (Infant)	100	100	100
Birth Date (Infant)	100	100	100
Discharge Date (Infant)	100	100	100
Birth Weight (g) - Infant	98	99	99
Gestational Age (Infant)	99	99	99
Transfer To	47	52	43
Skin to Skin Contact	90	94	93
Initial Feeding Type at Delivery	93	98	94
Initial Feed Type Newborn	97	97	97
Last Feed Type Newborn	97	97	97
Initial Feeding Method Newborn	94	94	93
Discharge Feeding Method Newborn	94	94	93
Feeding Type at Discharge	73	83	88
Feeding Type at Discharge Derived	100	100	100
Measured Weight	73	79	95

Neonatal Discharge Report

Variable	2018	2019	2020
Baby MRN	100	100	100
Financial Number	100	100	100
Payer Type	100	100	100
Forename	100	100	100
Surname	100	100	100
Date of Birth	100	100	100
Sex	100	100	100
Mother Ethnic Group	100	100	100
Newborn Blood Spot Due	66	70	62
Encounter Admission Date	100	100	100
Admission Date to NNU	86	94	91
Reason for Admission	87	92	89
Source of Admission	80	89	81
Encounter Discharge Date Time	100	100	100
Discharge Date from NNU	100	100	100
Discharge Time from NNU	100	100	100
LOS (NNU)	86	94	91
LOS Admit to Discharge (Days)	97	100	100
Professional Skilled Services	3	8	7
Infant Feeding on Discharge	97	94	94
Babies Last Location	100	100	100
Delivery Method description	85	94	96
Gestational Age	89	94	95
Admission Temperature	99	99	99
Birth Weight (g)	91	96	97
Last Weight Measured (g)	98	96	99
Last Length Measured	25	36	62
Newborn Birth Length	5	9	58
Birth Head Circumference	21	50	45
Last Head Circumference	91	87	78
Apgar Score 1 Min	85	93	93
Apgar Score 5 Min	86	93	93
1st Discharge Diagnosis	85	89	92
2nd Discharge Diagnosis	45	47	49
Discharged To	98	98	98
Discharged By	96	95	95
NICU Acuity	93	94	92

Pregnancy Loss Report

Variable	2018	2019	2020
MRN	100	100	100
Mother Name	100	100	100
Financial Number	100	100	100
Max Pregnancy Identifier	91	85	79
Pregnancy Loss Date & Time	100	100	100
Pregnancy Loss	99	98	98
Max Preg Start Date	100	100	100
Max Preg End	100	100	100
Max Date of Delivery	91	85	79
Max Delivery Outcome	91	85	79
Max Method of Delivery	91	85	79
Estimated EGA Date	90	84	79
EGA	90	84	79
Previous Births	49	42	28
Previous CS Ind	100	100	100

Appendix X: Clinical Handover and the Electronic Health Record staff survey from chapter 7

Describe the clinical handover process for you at formal handover

Do you take notes on paper and then type them up on word?

Do you use the e-chart or pen and paper?

What are your reasons for using either method?

When you are doing observations do you enter the information?

☐ Directly into electronic health record

☐ Write on paper

☐ Leave and enter later

☐ Other please specify_____

Do you feel you are given enough time with each patient to be able to complete the data in the room with the patient?

☐ Yes ☐ No

Do you feel comfortable completing data in the room with a patient?

☐ Yes ☐ No

What would ensure you use the e-chart for your observations throughout the day?

Do you use care compass?

☐ Yes ☐ No

If no why not?_____
If yes please explain 2 advantages of the system
_____
_____

When you are handing over a patient do you use the ISBAR tab on the e-chart if no why not?

☐ Yes

☐ No

If no why not?_____

If yes please explain 2 advantages of the system
_____
_____

On a scale of 1 to 5 how easy is it to find information on the e-chart?
1 – Being easy and 5 being difficult

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Are you concerned about data breaches on paper or on the e-chart?

Can you find the relevant data when handing over a patient or is it sometimes missing?

Do you think this is a risk?

☐ Yes ☐ No

Have you had to ask colleagues to complete data because it was missing or not in the place you would it expect to find it?

☐ Yes ☐ No

Do you think too much information is found in free text clinical notes as opposed to defined fields?

☐ Yes ☐ No

Do you think there is enough access to PCs for data updates?

☐ Yes ☐ No

Would hand-held devices/tablets make handover or your daily observations easier?

☐ Yes ☐ No

Would the use of a large screen and PC make handover easier?

☐ Yes ☐ No

Do you think you need more training on Care compass or the chart to use it more at handover?

☐ Yes ☐ No

Do you think it would be useful to have a PC with a large screen at the midwife station with a dashboard with all the patient details available?

☐ Yes ☐ No

Are you aware of data being saved anywhere else on the ward? For example ward logs/books etc.

Please outline 3 changes you would make to clinical handover

Any other comments

Appendix XI: Researcher's Personal Account

Undertaking this research has provided me with several positive challenges. Every clinical data point that a healthcare worker collects is a piece of a person, it is part of their story. Not only can it be used to improve outcomes for the patient, but it can improve services and systems. When I first started examining the data, I naively thought that the same mistakes would show up again and again however I soon found that there were no patterns emerging and multiple factors needed to be investigated. I needed to look at staff, patients, and service culture.

The potential of data once extracted, validated, and analysed from an EHR is fantastic. To be able to capture a women's care from their first antenatal visit to their discharge is remarkable. To be able to capture it for 7000+ women and babies in one unit is phenomenal. The power of an EHR cannot be underestimated, we are lucky to have such a dedicated national team that pushed for a patient cantered, clinically led system.

The maternity services in Ireland have always collected data and reported on it. I have worked in the National Perinatal Epidemiology Centre as a researcher since January 2015. I have held various roles from administration to policies and procedures to project manager. We have a very strong understanding of data in NPEC, and we acknowledge the clinicians who complete data for us. It is always an aim of the team to make data collection easier. Clinicians are busy people and as a national centre we have a responsibility to ensure the data we collect is easily collected. We also have a responsibility to ensure the data can be used by all. We strive to improve data collection, data dissemination, data cleaning and validation.

From this work I have learned the importance of a process. At times there is a need for a step-by-step practical approach to a problem. We can all get very engrossed in theory but for improvement there are times that practical solutions are required. Several times I found staff had already thought of a solution they just haven't had the confidence to capture data and drive a project forward.

In NPEC currently I am the post-partum haemorrhage quality improvement initiative project manager. This PhD afforded me the opportunity to explore change management for staff; to have the experience and learning from this project only strengthens my ability to work on the QII project and to achieve our goals.

My background is in social science and public health and these provided me with useful foundations to explore ideas and be able to use different techniques.

I found using the different methodologies allowed me to use action research to impact change. For me this research was always about learning lessons and examining how these could be used by others to influence change.

There is good data collected but better data could be collected. There are good practices but there could be better practices. We need to ensure that data is central to planning and used to impact change, improve outcomes for patients, and improve work environments for staff.

I am always enthused examining a data set with an epidemiologist and clinician and all bringing different ideas together. There is space for all of us in healthcare data we just need to recognise this element and come together.