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Maré, Irma Adele

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SUPPORT STRATEGIES FOR THE ADOPTION OF ELECTRONIC DATA CAPTURE SYSTEMS FOR BIOMEDICAL RESEARCH AND CLINICAL SERVICE DELIVERY RECORDS IN HETEROGENEOUS, RESEARCH INTENSIVE ORGANIZATIONS IN RESOURCE CONSTRAINED ENVIRONMENTS

A Dissertation submitted to the Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, in fulfilment of the requirements for the degree of: Master of Science in Medicine, specialising in Biomedical Informatics and Translational Medicine

Candidate:

Irma Adele Maré (Student number 691165 / OrcID 0000-0002-7054-9280)

Supervisors:

Prof Scott Hazelhurst, BScHons MSc (Wits) PhD (British Columbia)
Professor of Bioinformatics in the School of Electrical and Information Engineering; Associate Member, Sydney Brenner Institute for Molecular Bioscience

Dr Michael Klipin, BSc (Hons) MBBCh (Wits) FCS
Lecturer, Department of Surgery, School of Clinical Medicine, Faculty of Health Sciences

Gauteng, 2022

DECLARATION

I, Irma Adele Maré, student number 691165, declare that this Dissertation is my own work. It is being submitted for the Degree of Master of Science in Medicine, specialising in Biomedical Informatics and Translational Medicine at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.

I would also like to acknowledge that two publications may arise from this Dissertation, and that I will have contributed adequately towards each of them.

Signature of Student.....Date....1 March 2022.....

Name of Primary Supervisor: Professor Scott Hazelhurst

Signature of Primary Supervisor _____ Date....Mar 2, 2022.....

Scott Hazelhurst (Mar 2, 2022 08:43 GMT+2)

Agreement by co-authors: By signing this declaration, the co-authors listed below agree to the use of the article by the student as part of her Dissertation. In cases where the student is not the 1st author of a published article, the primary supervisor must explain (under comments) why the student is entitled to use the paper for his/her degree purposes.

Article 1: Title: Electronic Data Capture System (REDCap) for Healthcare Research and Training in a Resource-Constrained Environment: Technology Adoption Case Study
Journal name, year, volume, page numbers: JMIR Medical Informatics, submitted 14 Oct 2021, conditionally accepted 11 Jan 2022 pending revision and re-review, preprint available: http://doi.org/10.2196/preprints.33402

Authors	Name	Signature	Date
1st Author	Irma Maré		17 Feb 2022
2nd Author	Beverley Kramer	Beverley Kramer (Feb 28, 2022 08:58 GMT+2)	Feb 28, 2022
3rd Author	Scott Hazelhurst	Scott Hazelhurst (Feb 25, 2022 14:21 GMT+2)	Feb 25, 2022
4th Author	Mapule Nhlapho		Feb 28, 2022
5th Author	Roy Zent		Feb 28, 2022
6th Author	Paul Harris	Paul A Harris (Mar 1, 2022 05:46 CST)	Mar 1, 2022
7th Author	Michael Klipin		Feb 25, 2022

Comments by primary supervisor:

DEDICATION

I would like to thank my family – my partner Trevor, my daughter Lucy, my father Riaan and my mother Willemien for loving and believing in me.

I dedicate this dissertation to my mother, Willemien, for her creativity, to my father, Riaan, for his devotion, and to Mary, who was Mom when I couldn’t be.

PUBLICATIONS ARISING FROM THIS RESEARCH PROJECT

Two journal publications are planned for this project. The first paper has been submitted to the publisher and is undergoing review. The second paper in concept phase:

1. Maré IA, Klipin MJ, Hazelhurst S, Kramer B, Nhlapho MD, Zent R, Harris PA. Electronic Data Capture System (REDCap) for Healthcare Research and Training in a Resource-Constrained Environment: Technology Adoption Case Study. Submitted to: JMIR Medical Informatics on October 14, 2021. Conditionally accepted 11 Jan 2022 pending revision and re-review, preprint available: http://doi.org/10.2196/preprints.33402
2. Maré IA, Klipin MJ, Hazelhurst S, Kramer B, et al. Drivers, barriers and enablers of electronic data capture adoption at a health sciences faculty in South Africa: inductive thematic analysis of key informant interviews

ABSTRACT

Electronic data capture (EDC) systems in the health domain offer benefits like efficient management, aggregation and secondary use of data, real-time validation and quality control, improved data provenance, advanced analytics, precision medicine and bedside clinical decision support.

Like any technology implementation, user acceptance and adoption of an EDC system can be a critical obstacle post initial deployment. We used the implementation of the electronic data capture system REDCap at the Wits FHS as a case study to evaluate adoption support strategies for EDC technology implementation in research intensive and resource constrained health environments.

Firstly, we performed an inductive thematic analysis of interview transcripts with key informants at the Wits FHS to identify what the main perceived drivers, barriers and enablers of EDC adoption were in our environment. Secondly, we performed a retrospective analysis of the growth, usage patterns, research outputs and support strategies related to REDCap at the Wits FHS between 2013-2021.

Barriers to EDC adoption included fear of change, effort/benefit imbalance and lack of infrastructure and skills. Despite this, adoption of REDCap at Wits FHS spread rapidly to multiple different schools, and increased annually. This was facilitated by offering a system that was dependable, secure, user friendly and configurable, as well as support strategies like dedicated go-to technical officer, training workshops and regular academic meetings.

Ongoing challenges include the lack of capacity from clinical staff, development and retention of informatics skills, access to reliable networking infrastructure and the integration of data systems and policies between government and university.

ACKNOWLEDGEMENTS

I am humbled by the number of individuals who contributed to this work – through mentorship, guidance, and love. Without the incredible support I received, this project and research report would not have been possible.

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Many others have given their time, advice, and patience to me and to the creation of this work: Prof Paul Harris, Prof Beverley Kramer, Prof Roy Zent and Mapule Nhlapho in particular. To the individuals in the Faculty of Health Sciences who participated in interviews – though I cannot thank you by name, please know that I am immensely grateful for your time and insights.

I would like to acknowledge the support of the School of Clinical Medicine, and the Department of Surgery in particular, for providing protocol assessment, postgraduate administration, and open access publishing fees.

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NOMENCLATURE

4IR – the fourth industrial revolution

Bara – Chris Hani Baragwanath Academic Hospital

BMI committee – Biomedical informatics committee

CFR – Code of Federal Regulations

CRF – Case report form

Charlotte – Charlotte Maxeke Johannesburg Academic Hospital

CHBAH – Chris Hani Baragwanath Academic Hospital

CMJAH – Charlotte Maxeke Johannesburg Academic Hospital

COVID – Coronavirus disease

CSV – Comma separated value

HIPAA – Health Insurance Portability and Accountability Act

HIV – Human Immunodeficiency Virus

HR – Human resources

HREC – Human research ethics committee

HTML – Hypertext markup language

IT – information technology

ICT – information and communications technology

IDT – Innovation Diffusion Theory

EDC – Electronic data capture

EHR – Electronic health record

FDA – Food and Drug Administration

MO – Medical officer

NHLS – National Health Laboratory Service

FHS – Faculty of Health Sciences

LAN – Local area network

PACS – Picture archiving and communication system

POPIA – Protection of Personal Information Act

QC – Quality control

REDCap – Research Electronic Data Capture (Vanderbilt University)

SIMS – School Information Management System (Microsoft)

SPSS – Statistical software platform (IBM)

STATA – Statistical software platform (StataCorp)

TAM – Technology Acceptance Model

TRA – Theory of Reasoned Action

UJ – University of Johannesburg

UTAUT – Unified Theory of Acceptance and Use of Technology

Wi-Fi – wireless network protocols based on the IEEE 802.11 family of standards

Wits – University of the Witwatersrand

NOTE ON THE STRUCTURE OF THIS DISSERTATION

The University of the Witwatersrand Faculty of Health Sciences encourages the use of a publication model for research write-ups. The body of this dissertation (Part Two and Part Three) consists of two publishable papers, each with its own introduction, methods, results, and discussion sections. Some repetition exists between the general introduction in Part One of this dissertation and the introductions in the two papers, as each is meant to stand alone once published. Similarly, some repetition can be found between the general conclusion in Part Four of the dissertation and the discussion/conclusion sections of the two papers.

Secondly, there are formatting differences between the preprint article (Part Three) and the rest of the dissertation due to the submission requirements of the journal being different to the Faculty's dissertation style recommendation.

PART ONE - INTRODUCTION

1.1 General Introduction

Technology implementation projects often fail after the initial installation phase, and major contributors to this failure include lack of acceptance and adoption by end users (Davis, 1989; Rogers, 2003a; Poon et al., 2006; Welker, 2007; Ash, Anderson and Tarczy-Hornoch, 2008; Ford et al., 2009; Ruxwana, Herselman and Conradie, 2010; Murphy et al., 2012; Farzianpour, Amirian and Byravan, 2015; Ross et al., 2016; Venkatesh, Thong and Xu, 2016; Weng and Kahn, 2016; McLean et al., 2017; Furusa and Coleman, 2018; Shachak, Kuziemsky and Petersen, 2019).

The University of the Witwatersrand's Faculty of Health Sciences (Wits FHS) implemented a faculty-wide clinical research informatics tool called Research Electronic Data Capture (REDCap) (Harris et al., 2009; Harris et al., 2019) during 2012 (Klipin et al., 2014). The REDCap application, as well as the informatics support services that developed around it, have seen a sustained adoption and growth in demand from users in Wits FHS as evidenced by the number of users, projects and research outputs associated with its use. An analysis of the factors that contributed to successful post-implementation adoption can provide valuable guidance for our institution's future strategies and policy decisions, as well as for other institutions in resource constrained environments wishing to implement REDCap or similar electronic data capture systems.

Section 1.2. provides background to the problem and a review of literature relating to implementation and adoption of electronic data collection instruments in the health sciences domain. Section 1.3 outlines the objectives of the research. The methods and results are provided in the format of two stand-alone publishable papers in Part Two and Part Three, and an overall conclusion can be found in Part Four.

1.2 Background and Literature Review

1.2.1 Barriers to Implementation and Adoption of EDC

The advent of information technology and information networks provided an alternative to the traditional paper medium for the capture, storage and transmission of research and clinical data (Anderson et al., 2007; Welker, 2007; Ash, Anderson and Tarczy-Hornoch, 2008; Murphy et al., 2012; Owolabi, Mhlongo and Evans, 2016; Ross et al., 2016; Weng and Kahn, 2016; McLean et al., 2017; Katurura and Cilliers, 2018; Kumar and Mostafa, 2019).

There are benefits to switching to an electronic record keeping system: aggregation, recall and transmission of data is much faster than abstraction or sharing of physical records (Anderson et al., 2007; Welker, 2007; Ash, Anderson and Tarczy-Hornoch, 2008; Murphy et al., 2012; Owolabi, Mhlongo and Evans, 2016; Ross et al., 2016; Weng and Kahn, 2016; McLean et al., 2017; Katurura and Cilliers, 2018; Kumar and Mostafa, 2019).

Furthermore, systems that facilitate electronic primary data capture, as opposed to simply curating digitized records created by scanning physical media, present additional opportunities for data quality improvement in the form of real-time validation (Welker, 2007; Ross et al., 2016; McLean et al., 2017). The availability of structured data greatly eases aggregation and recall of data points that can be indexed and searched (Welker, 2007; Ross et al., 2016; McLean et al., 2017). Electronic data capture also allows for the introduction of coding and metadata standards, which increases the interoperability and aggregation potential of data even further (Weng and Kahn, 2016; Katurura and Cilliers, 2018).

Despite the benefits offered by reliable, structured electronic record keeping systems, implementation issues and lack of user acceptance can present significant obstacles to successful deployment and integration of a new technology into an organization (Davis, 1989; Rogers, 2003a; Poon et al., 2006; Welker, 2007; Ash, Anderson and Tarczy-Hornoch, 2008; Ford et al., 2009; Ruxwana, Herselman and Conradie, 2010; Murphy et al., 2012; Farzianpour, Amirian and Byravan, 2015; Ross et al., 2016; Venkatesh, Thong and Xu, 2016; Weng and Kahn, 2016; McLean et al.,

2017; Furusa and Coleman, 2018; Katurura and Cilliers, 2018; Shachak, Kuziemsky and Petersen, 2019).

Implementers are initially faced with the challenge of finding an application or suite of applications that fits the needs of their users, balancing this against affordability, concerns over security, access to and privacy of data, inability to host or operate highly complex pieces of software, and whether the new technology will be interoperable with existing systems already in use by the organization (Welker, 2007; Ash, Anderson and Tarczy-Hornoch, 2008; Ruxwana, Herselman and Conradie, 2010; Murphy et al., 2012; Ross et al., 2016; Weng and Kahn, 2016; McLean et al., 2017; Katurura and Cilliers, 2018; Kumar and Mostafa, 2019).

Successfully navigating these obstacles brings us to the post-deployment phase, where socialising a new technology and encouraging its adoption by users can present further challenges (Poon et al., 2006; Anderson et al., 2007; Welker, 2007; Ford et al., 2009; Ruxwana, Herselman and Conradie, 2010; Farzianpour, Amirian and Byravan, 2015; Furusa and Coleman, 2018; Katurura and Cilliers, 2018).

Decades of research have yielded several theoretical frameworks that attempt to explain technology adoption behaviour by looking at perceptions, expectations and motivation of users, social and organizational influences, and how these interact with individual characteristics like gender, age and personality traits (Davis, 1989; Agarwal and Prasad, 1998; Rogers, 2003a; Venkatesh et al., 2003; Ami-narh and Williams, 2012)

One of these, the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003) is noteworthy because it is an attempt to assimilate ideas from all the major preceding models into one, unified theory. Venkatesh *et al* compared and integrated the core concepts from eight pre-existing models, including the Theory of Reasoned Action (TRA) (Fishbein and Ajzen, 1975), the Technology Acceptance Model (TAM) (Davis, 1989) and the Innovation Diffusion Theory (IDT) (Rogers, 2003a), and tested their newly synthesized model to see if they could predict users' intention to adopt or reject a new technology.

Four key constructs were identified: performance expectancy (how much the user thinks they will benefit from adopting a technology), effort expectancy (how easy or complex the system is perceived to be), social influence, and facilitating conditions (how much support and capacity the user think their organization has). When combined with moderators like gender, age, level of experience and voluntariness of the adoption behaviour, the original UTAUT model could account for 70% of the variability in intention to adopt and about 50% of the variability in actual adoption outcome (Venkatesh et al., 2003).

Subsequent extensions have added new domains like hedonic motivation (how much users enjoy using the system), price value, and legacy system habit (Venkatesh, Thong and Xu, 2012), as well as the interaction between specific system features, environments and more nuanced distinctions of different outcomes or patterns of usage (Venkatesh, Thong and Xu, 2016). While not free of criticism (Bagozzi, 2007; Kumar and Mostafa, 2019; Shachak, Kuziemsky and Petersen, 2019), UTAUT and TAM are two of the most widely used models in health informatics technology adoption research, and both highlight how vitally important users' perception of effort versus reward of using a system are, though they are by no means the only determinants.

Ultimately, individuals are driven to change their process from a paper to an electronic medium either because they believe it will make the performance of their duties more efficient or because they are mandated to by their employer, oversight body or legislation (Poon et al., 2006; Anderson et al., 2007; Welker, 2007; Ash, Anderson and Tarczy-Hornoch, 2008; Ruxwana, Herselman and Conradie, 2010; Ami-narh and Williams, 2012; Ross et al., 2016; Katurura and Cilliers, 2018).

In any technology implementation scenario, there is typically a spectrum of users from "early adopters" to so-called "laggards" (Rogers, 2003b). Those eager to adopt usually require only that the technology is made available to them, but most will require additional actions from their organization before they adopt, whether in the form of support services, incentives, promotion and demonstration drives, or punishment in the form of legal/financial sanctions (Poon et al., 2006; Anderson et al., 2007; Welker, 2007; Ash, Anderson and Tarczy-Hornoch, 2008; Ruxwana,

Herselman and Conradie, 2010; Ami-narh and Williams, 2012; Ross et al., 2016; Katurura and Cilliers, 2018; Kumar and Mostafa, 2019).

Implementers must understand the environment that prospective users operate in, choose an appropriate system to meet their needs/address their concerns and carefully target implementation strategies to reduce barriers to adoption, as well as highlighting the particular benefits that prospective users consider important (Agarwal and Prasad, 1998; Rogers, 2003a; Poon et al., 2006; Anderson et al., 2007; Ash, Anderson and Tarczy-Hornoch, 2008; Ruxwana, Herselman and Conradie, 2010; Ami-narh and Williams, 2012; Ross et al., 2016; Venkatesh, Thong and Xu, 2016; Katurura and Cilliers, 2018; Shachak, Kuziemsky and Petersen, 2019).

1.2.2 Electronic Health Information Management in South Africa and the Wits Faculty of Health Sciences

The University of the Witwatersrand Health Sciences Faculty is a large heterogeneous organization that engages in research, teaching, and the provision of healthcare services (Kramer and Libhaber, 2018; About Us – Wits University, 2020). Each of these domains are accompanied by diverse data generating activities, as well as specific individual data consumption needs.

Firstly, the Faculty of Health Sciences trains and employs clinicians who provide healthcare services to the South African public in academic healthcare facilities owned and operated by the South African government's provincial Departments of Health. Healthcare service providers are legally required to keep records of their encounters with those who seek out their services (Owolabi, Mhlongo and Evans, 2016; Singh et al., 2018).

Secondly, healthcare providers working in teaching hospitals have a duty to contribute to the body of medical knowledge and training of the new generations of healthcare providers through clinical audit and secondary analysis of healthcare data. Thirdly, academic datasets and operational records are generated through research projects by students, clinical and scientific staff (Kramer and Libhaber, 2018).

Due to skills, resource and infrastructure constraints, Africa lags behind the developed world in the use of information technology and medical record keeping (Bukachi and Pakenham-Walsh, 2007; Ruxwana, Herselman and Conradie, 2010; Yogeswaran and Wright, 2010; Ami-narh and Williams, 2012; Cline and Luiz, 2013; Owolabi, Mhlongo and Evans, 2016; McLean et al., 2017; Furusa and Coleman, 2018; Katurura and Cilliers, 2018; Kumar and Mostafa, 2019).

The South African public healthcare system in particular still has significant challenges relating to resourcing and a unique quadruple burden of disease (Coovadia et al., 2009; Owolabi, Mhlongo and Evans, 2016; Katurura and Cilliers, 2018; Singh et al., 2018; Bradshaw et al., 2019), and implementation of electronic health records (EHR) has not been achieved, despite a recognition that the lack of such an information system exacerbates the resourcing and disease burden issues further (Coovadia et al., 2009; Ruxwana, Herselman and Conradie, 2010; Yogeswaran and Wright, 2010; Cline and Luiz, 2013; Owolabi, Mhlongo and Evans, 2016; Katurura and Cilliers, 2018; Singh et al., 2018; Bradshaw et al., 2019; Nicol et al., 2021).

From the Wits FHS perspective, the lack of EHRs meant that any work that required access to clinical information would include manually searching for patient folders in the academic hospitals' records department, and data would have to be abstracted *de novo* for each project. This was a major barrier to effective clinical and operational research. Many senior staff within the FHS had come to the same conclusion, and independently attempted to address the inefficiencies in record keeping by turning to localised, research-driven electronic data capture or management applications.

Before the implementation of REDCap in 2012, researchers and clinicians had a wide assortment of data collection tools ranging from various free or paid for off-the-shelf solutions to self-configured Microsoft Excel spreadsheets or self-developed electronic medical record applications commissioned and funded by large research units.

Over time, there was recognition that digitization of physical records might improve filing and expedite recall, but as an academic organization the ultimate value would

be achieved in simultaneously operationalising data for clinical care and re-use in research, and that would best be achieved by primary electronic capture (Ruxwana, Herselman and Conradie, 2010; Yogeswaran and Wright, 2010; Murphy et al., 2012; Cline and Luiz, 2013; Katurura and Cilliers, 2018; Singh et al., 2018; Kumar and Mostafa, 2019).

Comprehensive structured electronic data capture unfortunately takes longer to do than unstructured records like paper summaries (Poon et al., 2006; Welker, 2007; Ash, Anderson and Tarczy-Hornoch, 2008; McLean et al., 2017), and in a resource constrained environment like the one Wits FHS operates in, appointing dedicated staff to deal with data capture would generally not be feasible unless it is supported by research grant funding (Kumar and Mostafa, 2019).

In most cases, data was captured by clinical staff, and to minimize the burden of this additional duty, highly specific and customised data capture instruments and workflows that fit intimately within their operational processes had to be created (Poon et al., 2006; Murphy et al., 2012; Ross et al., 2016; Katurura and Cilliers, 2018; Kumar and Mostafa, 2019). This meant that electronic forms and processes created for one group could not easily be duplicated or scaled up for use in another unit.

Yet, unless an institutionally sanctioned solution could be offered, data services within the Wits FHS' clinical spaces would continue to fragment, as departments chose products or applications most suitable to their individual needs, abilities, and budget. This fragmentation posed a risk to the organization, as the datasets they generated were isolated, the financial and human resources used for management were diluted and without careful vetting of the products used security and privacy of data could not be guaranteed (Ash, Anderson and Tarczy-Hornoch, 2008; Ruxwana, Herselman and Conradie, 2010; Murphy et al., 2012; Owolabi, Mhlongo and Evans, 2016; Ross et al., 2016; Katurura and Cilliers, 2018).

The Wits FHS established a Biomedical Informatics committee (BMI committee) in 2011, tasked with scoping the electronic data management needs at the faculty, identifying potential solutions, and ultimately implementing those solutions. Because

of resource constraints, the BMI committee preferred information systems that could support both clinical and basic scientific research data management needs, and the main contenders were free or open-source technologies that could be self-hosted and configured (Klipin et al., 2014).

1.2.3 Implementation of REDCap at Wits FHS (2012-2013)

REDCap was an attractive option due to the freeware licensing model and large international support community (Harris et al., 2019), as well as Diaspora linkages between Wits FHS and REDCap's parent organization Vanderbilt University (Kramer and Zent, 2019).

One of REDCap's most distinguishing features was the ease with which end-users could configure their own data capture instruments and workflows (Harris et al., 2009). In contrast to other options under consideration at the time that all required some level of software development skill to customise on an end-user level, REDCap allowed most clinicians and scientists to 'build their own' data capture forms and workflows even if they had only basic computer skills.

Secondly, REDCap was built with the aim of enabling compliance with HIPAA (the Health Insurance Portability and Accountability Act) (Health Insurance Portability and Accountability Act of 1996 (HIPAA) | CDC, 2019) and FDA Title 21 CFR part 11 (Food and Drug Administration's Code of Federal Regulations title 21 part 11: Electronic Records; Electronic Signatures) (Office of the Commissioner, 2020).

Standards like HIPAA have basic requirements for the environment into which server software like REDCap is installed, and true compliance relies on correct security, backup and maintenance practises by the host institution (Is REDCap HIPAA-compliant?, 2021).

Similar requirements for safeguarding of individuals' personal information through the use of reliable applications and appropriate security practises is required by the South African Protection of Personal Information Act (POPIA), which was implemented in July 2020 and is currently being enforced after a grace period of one year (Accessible Law, 2020).

For this reason, web-based applications like REDCap require a highly competent IT individual or team to install and maintain. One of the main barriers to implementation at the Wits FHS was a dearth of the appropriate IT skills within the faculty to set up and maintain a server. The Wits University IT Department did not have the resources or mandate to provide hosting services for non-core business applications, and the scientific or clinical backgrounds of most faculty staff made this task beyond their ability.

Resolution came about in the form of a partnership with an existing research computing cluster dedicated to bioinformatics. This partnership, as well as other strategies to facilitate the initial implementation is described in a 2014 paper by the BMI committee (Klipin et al., 2014).

1.2.4 Problem Statement

Technology implementation projects often failed after the initial deployment due to resistance and lack of adoption by end-users (Davis, 1989; Rogers, 2003a; Poon et al., 2006; Welker, 2007; Ash, Anderson and Tarczy-Hornoch, 2008; Ford et al., 2009; Ruxwana, Herselman and Conradie, 2010; Murphy et al., 2012; Farzianpour, Amirian and Byravan, 2015; Ross et al., 2016; Venkatesh, Thong and Xu, 2016; Weng and Kahn, 2016; McLean et al., 2017; Furusa and Coleman, 2018; Katurura and Cilliers, 2018; Shachak, Kuziemsky and Petersen, 2019). The Wits FHS implemented the REDCap EDC system in 2012 and applied several support strategies to encourage adoption by Faculty members. This project is an evaluation of the drivers, barriers and enablers of adoption at the Wits FHS, an audit of the adoption patterns and EDC's impact on research outputs, as well as a critical review of the adoption support strategies employed by the Wits FHS. Through this in-depth evaluation of a successful EDC adoption strategy, we hoped to both provide a resource to other groups planning to implement EDC in research intensive and resource constrained environments, and better understand the ongoing challenges and areas for improvement in our own setting.

In part two of this report, we identify and discuss the factors that influenced user acceptance of REDCap and other EDC technologies at Wits FHS.

Part three describes the post-deployment period of REDCap (2013-2021), which was characterized by rapid and sustained growth of users, data capture projects and research outputs. We evaluate the various strategies followed by the BMI committee to overcome adoption barriers and support users in the Wits FHS.

In the concluding chapter, we summarize the main lessons learned, identify where improvements could be made, what challenges remain to still be overcome, and provide a set of guidelines to be used by EDC implementers in research intensive and resource constrained environments.

1.3 Study Objectives

The main objective of this study was to evaluate the adoption support strategies of an electronic data capture system in a research intensive and resource constrained environment by using REDCap at Wits FHS as a case study. The objective was achieved by through four sub-objectives (also see Figure 1.1):

1. Identification of the drivers, barriers and enablers of adoption of electronic data capture systems through inductive thematic analysis of key informant interviews
2. Quantification of REDCap adoption and growth at Wits FHS during the post-deployment period of 2013-2021 by auditing administrator records and system logs and reporting metrics like number of active users and projects
3. Illustration of REDCap's impact on the Wits FHS research outputs through bibliometric survey of scholarly publications and postgraduate monographs that cite the use of REDCap
4. Critical evaluation of the adoption support strategies used to overcome some of the barriers to adoption

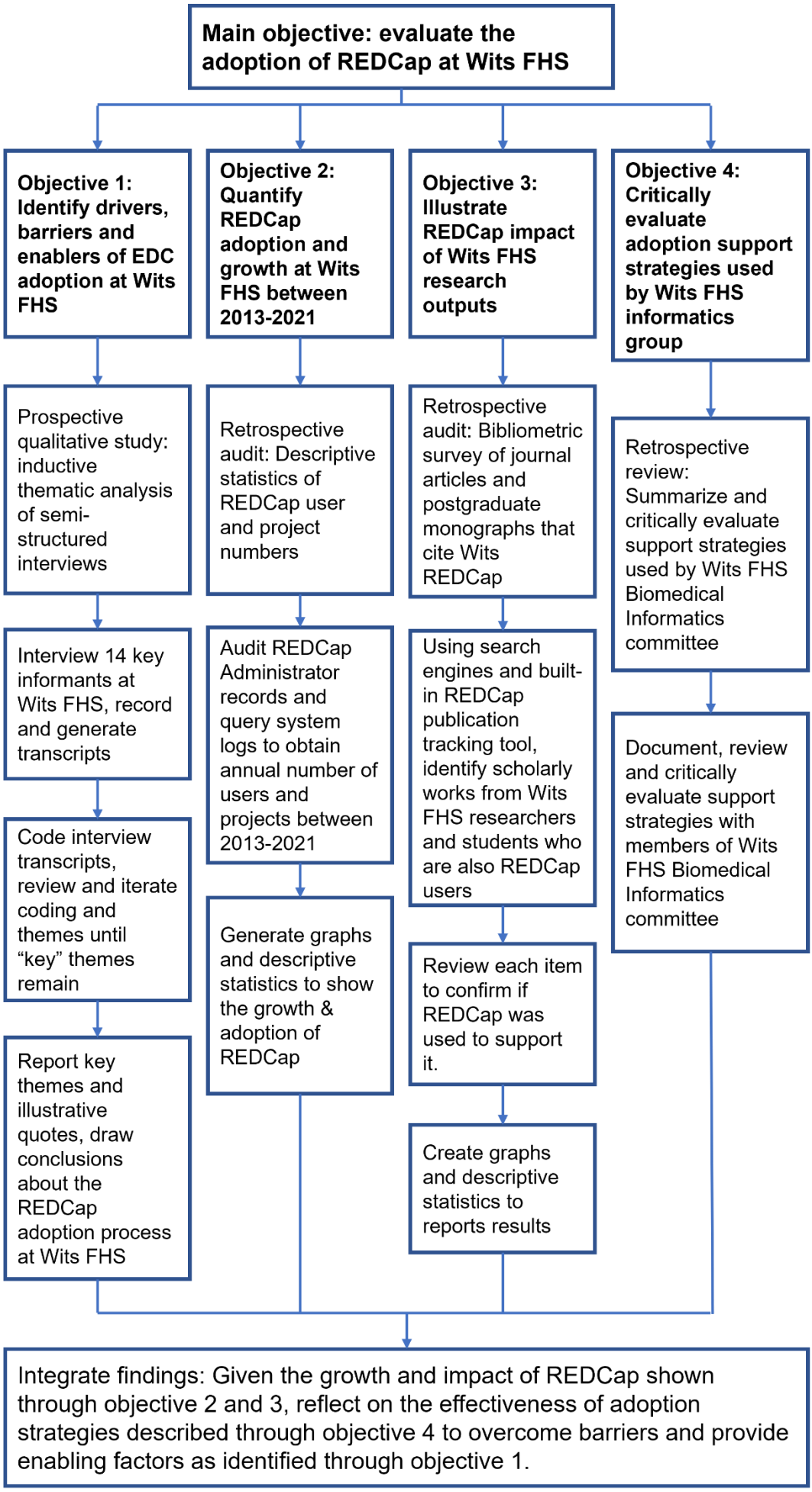

Figure 1.1 Research process diagram

The methods, results and discussion of these objectives are reported in the form of two publishable papers, which according to FHS guidelines are supposed to be self-standing chapters. Hence, there is a small amount of repetition between Part Two and Part Three, as well as variations in the formatting of headings and references, since the journal requirements from Part Three differs from the FHS Dissertation style guide applied to Part One, Part Two and Part Four.

The first publishable paper (Part Two of the Dissertation) deals with objective 1 in the form of a prospective qualitative study with key informant interviews at the Wits FHS to identify drivers of EDC, ongoing barriers facing implementation and factors that ease or enable implementation. Fourteen individuals that have leadership, research coordination or data management roles at the Wits FHS participated in semi-structured interviews that were conducted and recorded using Microsoft Teams. Interview transcripts were transcribed within MS Teams, and then imported into Atlas.ti for an inductive thematic analysis. Through iterative rounds of coding and review, key concepts were taken from the interview transcripts and organised into ten main themes that relate to drivers, barriers and enablers of EDC adoption. The themes and illustrative quotes are discussed against the backdrop of implementation strategy, and areas that require improvement from the Wits FHS perspective are identified.

The second paper (Part Three of the Dissertation) encompasses objectives 2-4 in the form of a retrospective audit of the growth, impact, and support strategies of the Wits FHS REDCap initiative. Adoption was quantified by reporting the growing number of users and projects on the Wits FHS REDCap system every year for the period 2013-2021. We showed the impact on research outputs through a bibliometric survey of the number of scholarly publications and postgraduate monographs that cite the use of the Wits FHS REDCap system on a yearly basis between 2013-2020. Additionally, an analysis of the subject domains of the research articles showed the diversity of disciplines using REDCap at Wits FHS. Finally, we summarized and critically reviewed seven core support strategies employed by the informatics unit to encourage adoption, retain and engage existing users, and develop informatics skills and human capital within the Wits FHS.

In the concluding chapter (Part Four of the Dissertation), the results of the two studies are integrated and a summary of strategies to overcome barriers to EDC in research intensive and resource constrained environments is presented.

Permission to perform the research was obtained from the Wits Department of Surgery postgraduate protocol committee, the Wits Human Research Ethics Committee and the Wits University Registrar (see Appendices B-D).

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PART TWO - DRIVERS, BARRIERS AND ENABLERS OF EDC ADOPTION

AT A HEALTH SCIENCES FACULTY IN SOUTH AFRICA: INDUCTIVE THEMATIC ANALYSIS OF KEY INFORMANT INTERVIEWS

2.1 Introduction

Electronic data capture systems hold many benefits for individuals and organizations (Anderson et al., 2007; Welker, 2007; Ash, Anderson and Tarczy-Hornoch, 2008; Murphy et al., 2012; Owolabi, Mhlongo and Evans, 2016; Ross et al., 2016; Weng and Kahn, 2016; McLean et al., 2017; Katurura and Cilliers, 2018; Kumar and Mostafa, 2019) but can be challenging to implement (Bukachi and Pakenham-Walsh, 2007; Welker, 2007; Ash, Anderson and Tarczy-Hornoch, 2008; Ruxwana, Herselman and Conradie, 2010; Yogeswaran and Wright, 2010; Murphy et al., 2012; Ross et al., 2016; Weng and Kahn, 2016; McLean et al., 2017; Katurura and Cilliers, 2018).

One of the challenges is lack of acceptance and adoption by end-users (Poon et al., 2006; Anderson et al., 2007; Welker, 2007; Ford et al., 2009; Ruxwana, Herselman and Conradie, 2010; Farzianpour, Amirian and Byravan, 2015; Furusa and Coleman, 2018; Katurura and Cilliers, 2018).

Some of the factors that affect adoption could also be considered organizational implementation barriers, like the need for policy, infrastructure, and skills (Ash, Anderson and Tarczy-Hornoch, 2008; Ruxwana, Herselman and Conradie, 2010; Owolabi, Mhlongo and Evans, 2016; Ross et al., 2016; Katurura and Cilliers, 2018).

However, there are issues that affect end-user acceptance and adoption that are cultural, social or relate to the individual needs and perceptions of the prospective users of a system (Welker, 2007; Ash, Anderson and Tarczy-Hornoch, 2008; Ford et al., 2009; Ruxwana, Herselman and Conradie, 2010).

Understanding both the organizational and individual behavioural factors that drive, hamper or facilitate adoption in a certain setting allows an organization to choose appropriate systems and tailor their policies and implementation strategies to overcome the challenges specific to their context (Poon et al., 2006; Anderson et al., 2007; Welker, 2007; Ash, Anderson and Tarczy-Hornoch, 2008; Ruxwana, Herselman and Conradie, 2010; Farzianpour, Amirian and Byravan, 2015; Owolabi, Mhlongo and Evans, 2016; Ross et al., 2016; Katurura and Cilliers, 2018).

The purpose of this paper is to examine the pertinent individual, social and organizational factors that affect technology acceptance and adoption at the University of the Witwatersrand (Wits) Faculty of Health Sciences (FHS).

2.2 Background

The Wits FHS is a large heterogeneous organization that engages in research, teaching and the provision of healthcare services (Kramer and Libhaber, 2018; About Us – Wits University, 2020). Each of these domains are accompanied by diverse data generating activities, as well as specific individual data consumption needs.

Core business processes like finance and HR systems were some of the first electronic data capture applications to gain a foothold at the Wits FHS, and more recently electronic research data management (Klipin et al., 2014; Maré et al., 2021) and online teaching systems (Ravat, Barnard-Ashton and Keller, 2021) have been implemented.

However, as of the writing of this paper, the Wits FHS does not yet have access to an enterprise-wide electronic health record (EHR) solution in the public health sector where it has a footprint – partly because the mandate to provide such a system lies with the provincial governments of South Africa, and not the Wits FHS (Owolabi, Mhlongo and Evans, 2016; Katurura and Cilliers, 2018).

The South African public healthcare system has significant challenges relating to resourcing and a unique quadruple burden of disease (Coovadia et al., 2009;

Owolabi, Mhlongo and Evans, 2016; Katurura and Cilliers, 2018; Singh et al., 2018; Bradshaw et al., 2019), and implementation of EHR has not been prioritised, despite a recognition that the lack of such an information system exacerbates the resourcing and disease burden issues further (Ruxwana, Herselman and Conradie, 2010; Yogeswaran and Wright, 2010; Cline and Luiz, 2013; Owolabi, Mhlongo and Evans, 2016; Katurura and Cilliers, 2018; Singh et al., 2018; Nicol et al., 2021).

Various groups within the Wits FHS and public health domain have resorted to implementing their own localised solutions to meet their needs (Murugan et al., 2014; Ballot et al., 2015; Technau et al., 2017; Kramer and Libhaber, 2018), but we consider it inevitable that either these systems will eventually be assimilated into provincial or national enterprise-wide platforms, or remain distinct but form part of an integrated clinical data exchange. Either way, a major shift in the way clinical information is managed is on the horizon in South Africa, and a deeper understanding of implementation and end-user acceptance issues may ease the transition and reduce wasted expenditure or effort.

By examining the experiences and perceptions of Wits FHS staff based on their interactions with electronic data capture tools, including generic spreadsheet applications (MS Excel), eLearning platforms, electronic clinical and research informatics systems, and electronic health record instruments, we aim to understand the factors that are most pertinent to EDC adoption in our context. This can support adoption strategies for existing systems and inform planning for future systems, including an EHR system.

2.3 Methods

2.3.1 Key Informant Interviews

Fourteen key informants from different departments and research units at the Wits FHS were invited to participate in semi-structured interviews with the researcher. The informants were selected based on their role in leadership, research coordination or data management positions, and asked to volunteer for a 30–40-minute interview using Microsoft Teams.

Candidates completed and signed an electronic consent form designed using the REDCap (Harris et al., 2009; Harris et al., 2019) platform hosted at the University of the Witwatersrand. Our aim was to interview 3-4 individuals from each of the following categories: leadership, clinical data management, research coordination and research data management. Most of the informants who agreed to the interview could be associated with more than one of the categories (Table 2.1).

Table 2.1. Key informant role categories

	Leadership	Student/ research coordination	Research data management	Clinical service delivery records
Informant1		■	■	
Informant2		■	■	■
Informant3		■	■	
Informant4			■	
Informant5			■	
Informant6			■	■
Informant7	■			
Informant8	■		■	■
Informant9	■			
Informant10		■		
Informant11	■		■	
Informant12		■	■	
Informant13			■	■
Informant14	■			

Five informants were in leadership positions (for example heads of schools or departments). Five informants were involved with student and research coordination within their schools or departments, four were involved with managing clinical service delivery records or patient health records, and 10 informants were involved with management of research data.

The interview questions were developed by the principal investigator and research supervisors, in consultation with domain experts who collaborated on this paper. In line with the inductive research approach we chose, the purpose of the questions

was to provoke a discussion with the key informant around the topic of drivers, barriers and enablers of EDC, so that unanticipated themes might have an opportunity to emerge.

2.3.2 Coding and Thematic Analysis

The interviews were recorded, and transcripts were auto-generated within Microsoft Teams. The transcripts were imported into Atlas.ti (version 9 for Windows, Scientific Software Development GmbH), where they were checked for accuracy against the recordings and any mistakes in the text were corrected.

The first round of open coding was performed with an inductive, data-driven approach to allow for the discovery of unanticipated themes (Braun and Clarke, 2006). More than 500 codes were generated and mapped to 288 quotes of interest during the first round of analysis. Many different themes that relate to technology implementation, human/technology interaction and organizational behaviour could be recognized in this very rich, very broad overview.

Through several rounds of review and refinement, open codes were grouped together into sub-themes and themes. Key themes that relate to our research question, namely drivers, barriers and enablers of EDC adoption were selected for reporting in this paper. The “keyness” of the theme was based on the researcher’s opinion, informed by their experience with the implementation and support of REDCap at the Wits FHS, and by comparing the current results set with other inductive technology adoption studies. Key themes and illustrative quotes are summarized in sections 2.4.1-2.4.10. Extended transcript excerpts supporting each of our themes are included in tables in appendix E.

2.3.3 Editing of Transcripts

Privacy:

Any comments that could identify the informant were redacted. These include references to their own Department (though when speaking about other departments or facilities these were left unredacted), specific project names or names of other individuals in the organization. The redacted text was replaced by a generic comment in capital letters, for example when the informant refers to their department

by name, the redaction is (DEPARTMENT NAME). When they refer to a colleague by name, the redaction reads (PERSON NAME).

Readability:
Where necessary for readability, duplicate words or stuttering and fillers like ‘um’, ‘like’ or ‘you know’ were removed. Where more than one filler word was removed, an ellipsis (…) is used to mark the place where text was removed. In cases where words were mispronounced or incompletely pronounced and sentence meaning is severely impacted, the correct word was added in brackets by the researcher.

2.4 Results

Key themes and associated codes are reported in Tables 2.2-2.11. Each theme is also briefly discussed together with illustrative quotes from the interview transcripts. More extensive transcript excerpts supporting each of the themes can be found in the Appendix E.

We report on mandated or involuntary adoption as a driver of EDC in section 2.4.1, followed by drivers of voluntary adoption in sections 2.4.2 and 2.4.3. Two organizational barriers to implementation that are also obstacles when it comes to adoption are discussed in section 2.4.4 and 2.4.5. Section 2.4.6 and 2.4.7 relate user perception themes that affect adoption, while sections 2.4.8-2.4.10 are discussions of supportive or enabling factors that facilitate acceptance by technology end-users.

2.4.1 Involuntary Drivers of Adoption: Mandates, Pressure and Punishment

Table 2.2. Summary of the theme “Involuntary adoption: Mandates, pressure and punishment” and related codes

Domain: Drivers	
Theme: Involuntary adoption: Mandates, pressure and punishment	
Codes:	
Employer/ regulatory body mandates	Some positions mandate the use of a specific data capture tool, or mandate the production of electronic aggregate data, but leave the choice of capture system up to the individual. Non-compliance may result in termination of employment or revocation of medical licensing
Research funder requirement	Research funders sometimes mandate a specific system, or specify a set of requirements but leave the choice of system to the researchers. Non-acceptance of the sponsor terms would result in loss of research funding
Influence by managers/ supervisors	Even when not explicitly mandated by job description, leaders and managers can set explicit requirements or implicit expectations for those they supervise. Students often use a data management tool preferred by their research supervisor

Our informants acknowledged that in some cases, the use of a certain technology or EDC is an explicit and formal requirement of a certain job or research funding opportunity (Table 2.2):

> *Informant8 18:29: “because that's your job requirement, it's just an expectation that you just do it. It's part of your job.”*

> *Informant4 10:36 “And then for sponsored studies where …. we don't need to worry about budget in how we store our data. They'll usually have a database platform that …. goes in line with their systems.”*

There are also cases where adoption is not voluntary but is also not due to an explicitly stated institutional mandate (table 2.2). We found examples of pressure by students, peers, managers, and supervisors to adopt a certain EDC system discussed by our informants:

> *Informant10 29:54 “And I also think … we were forced into it a bit just because … those are the times we're living in… and the students coming up under us are so savvy and they know all of these things and we’re kind of pushed into adopting some of these methods as well…”*

Informant6 13:34: "Yeah, so I think it was really just pressure... He had to record the information either way, which he did, but I kept on pushing him… so that our systems can work on the same medium."

Mandated adoption is not seen as ideal when used in isolation, without any incentivizing or 'positive' drivers, as it is associated with resentment and resistance:

Informant9 17:09 "… one of the things that I think might be of some value at some stage is that we enforce as from the Health Professions Council some form of audit of practices. Yeah, people will do it begrudgingly, and I know that … an angry person putting data in will give you an angry outcome. But … the fact is… poor data is better than no data."

Informant7 14:05 "And quite often you have to remind people. Almost shame them sometimes, by saying I still haven't received from you. And you don't want to do that, you want it to be an upwardly mobile type of approach. But you get so frustrated .... So usually I send the graph out and I leave out the missing bit and I say I'm missing this. … which is a fact, but it's not really the way I want to do things"

In a section 2.4.8 we also discuss the role of social pressure as enabler in a voluntary adoption scenario rather than as a punitive measure.

2.4.2 Drivers of Voluntary Adoption: Downstream Benefits/ Efficacy Gains

Informants at our institution frequently referenced the downstream benefits of having aggregate electronic data rather than direct benefits of EDC as a driver for adoption (Table 2.3). This is important because, as we discuss in section 2.4.7, disconnecting a user from the downstream benefits of an electronic EDC system leads to a lack of motivation, and the capture process is rarely seen as rewarding in and of itself.

Table 2.3. Summary of the theme: "Downstream benefits/ efficacy gains: I can do more, faster and I can trust the results" and related codes

Domain: Drivers
Theme: Downstream benefits/ efficacy gains: I can do more, faster and I can trust the results
Codes:

Aggregation, reporting and analysis	Structured electronic data is easy and quick to search, aggregate or process for reporting or analysis
Re-use/ secondary analysis	Once data has been captured electronically, it can be used/re-used in many different scenarios
Data provenance	Electronic systems provide logging and enhanced audit capacity to ensure veracity and provenance of research data and medical records

Many different desirables features of an electronic data capture system were mentioned based on each informants' specific needs and role in the institution, but most of them were either currently or previously involved in basic or clinical research of some sort, and there seemed to be a general feeling that electronic data curation tools increased their efficacy in terms of how much data they can aggregate, and how long it takes them to analyse and produce reports:

> *Informant1 22:38 "So I think it's that having the information at the tip of your fingers rather than having … paper files to find and sift through. I think the nice thing is also you can … search (an) electronic database to find specifics. … and I think … it would be easier to … get rid of the duplicate entries." Informant1 23.26 "So … obviously also the fact that electronic data is the only way we can analyse data. It's the only way that we can import it into statistical software and get nice inferential statistics from it, so obviously that's super important."*

> *Informant10 28:06 "I think the benefits of having that electronic data capture is that you can have a lot of information in one place, … so there's centralization of your information. It's much more easily accessible. It's much easier to track. You're not going to lose your bits of paper, and … have your records go missing. It's space because … if I think about like patient records, … having cabinets and cabinets full of patient files versus having all of that information in a (file) on a USB or something, …it's just incomparable. So it's storage space, the ease of access, the centralization of the data. Those are all things that I think are benefits that would drive it"*

Logging and audit trails were also held as benefit of electronic data curation systems, as there is increasingly a burden on clinical researchers to find some mechanism of proving the provenance of their data.

> *Informant3 25:12 "One of the issues that the university is going to have to grapple with is data provenance and audit trails for data, (especially) since data fudging is becoming more and more common. … I don't know how much it's happening at Wits. If it is happening at all, I have no idea, but it is something that's a worldwide phenomenon. … and it seems to be data fraud seems to be increasing."*

> *Informant9 08:43 "Obviously I mean one of the things you always wanted out of the raw data environment was accuracy and … you and I know how much fudging goes into even entering information into … a... data collecting system, whatever that system is"*

> *Informant14 23:50 "I have had to audit some of the findings that the HIV world and the quality of that data entry is often very, very poor. Not all of it, but some of it is very good. But often it's very poor. … we have had to deal with situations where data's (entered) and you go in and you do an audit and you find data entered three days ahead. … and every doctor or nurse will tell you the story of going to certify a dead patient and finding blood pressure results entered in until tomorrow morning."*

Several informants mentioned that the primary purpose of the system doesn't necessarily have to be data collection, but various processes – like physician order entry or service evaluation surveys – generate data as a by-product if they are conducted on an appropriate electronic platform.

> *Informant9 13:46 "in the …clinical setting …the one that really always makes sense, … is if you are able to get people to minimize what they do, say … you have an auto generated discharge summary. After people having to enter data because … they need to, for instance, be able to get a medicine … and there's (prescribing). You can do electronic prescribing, or you can order blood results or you can order blood tests online and you get the results back immediately or you get it online again without any purpose, so that it kind of falls into the normal workflow. And … today none of us have any difficulty going onto a computer and putting in information that gives us access to something of that kind of nature, and that we then get the secondary data back."*

Unfortunately, as we discuss further in the theme about organizational barriers (section 2.4.4), lack of cooperation and integration between different organizational units or between our institution and governmental departments of health limit the

extent to which data can be shared and re-used, leading to parallel systems and duplicate efforts.

> *Informant14 36:44 "Just trying something small, like the NHLS, is trying to work out those politics. Trying to find a way of harmonizing that without all the drama and the politics, would be just so useful. And trying to …look at radiology, trying to work out how to harmonize and digitize all of that stuff and link it to the pharmacy. Look at prescribing practices and things,… that could be gold."*

2.4.3 Drivers of Voluntary Adoption: Obviating Transcription

When we examined informants' comments that relate to EDC in particular, and not to downstream benefits or advantages of electronic data aggregation systems in general, we found that the main driver they mentioned was the removal of the paper to electronic transcription processes, with its resultant decrease in data turnaround times, and error reduction due to real-time validation and data input formatting constraints (Table 2.4).

Table 2.4. Summary of the theme "Obviating transcription: It all happens in real time" and related codes

Domain: Drivers	
Theme: Obviating transcription: It all happens in real time	
Codes:	
Turnaround time reduction	By using primary electronic data capture, the turnaround time associated with paper document transcription is eliminated. Data is available for quality control, analysis or reporting immediately after capture.
Capturing twice / capturing on paper	Mistakes are inevitably made both when data is entered into a paper CRF and when paper documents are transcribed into an electronic system. By removing the paper capture step, one of these two opportunities to introduce errors is removed. Paper records are also often handwritten, with varying levels of legibility
Error reduction	Electronic data capture systems can be configured to ensure data formatting standards and logical data quality rules. Since these are in place at point of capture, a mistake can be corrected while the patient/research participant is still present, while errors with paper records are usually discovered long after the subject's encounter has ended.

By using electronic source documents, it becomes possible to produce reports immediately and on demand, rather than having to wait for source material to be captured, which informants describe as often taking months. These delays not only impact the production of research results but also prevents early detection of workflow or quality issues:

> *Informant13 28:47 "for us the main reason why we had to move, … it was taking a lot of time. … you collect the data, then you need to have people that are entering the data into the database, then you also you need to have people that are checking the data. So, when we were on paper, it used to take us at least… four months from the time that we finish one census round, to the time that actually we have a data set that is ready for analysis. And to cut this, this was one of the motivating factors to say, no, we're taking too much time to get the data ready. If we move to an electronic system, the data will be available immediately. If we collected the data today, tomorrow we should be able to produce a … data quality report on the data that we collected today to say, these are the mistakes that were done in the field, can you go and correct them? Where, in the past, sometimes we pick up some of these errors after the contracts with the fieldworkers have already been…ended, and when we don't have the fieldworkers to go back to these individuals and … correct the mistakes. So apart from getting the data processed …on time, and the … other field was that … improvement in the quality of the data. Because … we can pick up issues and fix them in real time. I think these are the two main drivers"*

> *Informant11 07:21 "and what happens is you create a very big data vacuum because someone can't enter data, or data is collected, it's not checked, it's not entered, it's not QC'd, it's not anything and you just need that to go on for a few months and suddenly you have stacks of paper that high, and then you introduce a huge amount of human error. And so we had all of this, … then they started entering the data into the database, and when we had it checked, it was like 17% of the data were wrong, 12% of the data were missing. Now those patients have come and gone so we can't go back."*

Turnaround times related to investigation results are also incredibly relevant when it comes to patient management and electronic health records, and informants mentioned the positive impact of having electronic results available 'at the bedside' as reasons why they would support efforts to implement electronic health records:

> *Informant1 22:10 "I think it's obviously just the ease of use, and having it readily available and if I just think of … some hospitals in private would have (an) electronic app where the doctor immediately gets the patients' results on*

his phone. So the data is immediately available to him to make a decision, at the bedside."

Furthermore, well-designed electronic data capture interfaces reduce errors by enforcing standardised formatting, introducing logical constraints, and actively alerting the user when errors or inconsistencies are detected:

Informant12 21:26 "the only thing that I would say is that I would never collect data that is not electronic … in terms of a research project going forward. Whether it's interview administered or whether it's self-administered, absolutely, I would not even consider it. It's transformative. I think the level of errors and all of that sort of thing is just so vastly reduced"

Informant11 14:09 "You know… I would prefer a system … and I know it's asking a lot, but … rather than me going to it, it comes to me when something is wrong."

There is also a cost implication to having two data capture processes instead of one, and while some informants feel there is a reduction in overall research costs, others feel there has merely been a shift in how their human resources are used from focusing on capture to focusing on quality control processes:

Informant13 32:24 "It increased also the workload for the data management team, because when we should be able to process the data but there are lots of data in real time. … so we had to add more people into the data management team and unlike in the past, … while we saved the costs in terms of the data enterer, but we also increased the cost in terms of data management personnel."

In section 2.4.10 we further discuss specialist training and dedicated data management roles as an enabling factor for EDC adoption.

2.4.4 Implementation Barriers That Affect Adoption: Lack of Integration

Table 2.5. Summary of the theme "Lack of integration between systems, departments, and organizations" and associated codes

Domain: Barriers
Theme: Lack of integration between systems, departments, and organizations
Codes:

Lack of integration	No enterprise-wide electronic health record systems are available in the public health facilities. Some localised solutions are implemented by departments, but not integrated with the organization as a whole
Data privacy and governance	The SA public health system encompasses different organisations operating in the same service delivery spaces, but sharing of clinical data between organizations and even departments are fraught with legal, bureaucratic and logistical issues.

As discussed in the background section, there are no facility-wide, provincial, or national electronic health records available in the public healthcare facilities where our institution operates, though electronic laboratory information systems and some hospital-level electronic clerking systems exist. Furthermore, there are many examples of isolated departmental solutions in response to the lack of electronic health records, often framed as 'research repositories' to avoid overstepping the university's mandate and intrude on the turf of the government. Due to tension between the different organizations (government, university, national health laboratory system) over infrastructure and staffing costs to capture data and the ownership, access or governance of the data, the potential for aggregation and re-use both for research and patient care is not realised (Table 2.5).

> *Informant2 26:54 "much as we realize the limitations of our current government, … in as much as … they're not reliable, we have to find a way of pulling them closer because it will be very difficult to convince the doctors and also and make it compulsory for everyone to collect this data without the involvement of the Department of Health, without the involvement of … government in general, so you have to find a strategy of pulling them in, working closely with them and not against them, because ultimately the data actually belongs to the Department of Health, or … Gauteng or government, … it does not belong to the universities. The universities are custodians and they have to, if they want to really integrate the data collection process with the workflow, they have to bring in the comrades, you have to bring in the premiers and everyone else who's a stakeholder and make them understand why it's important, … just go down to their level and speak in terms of cost versus benefits and things like that, … stoop down to the level and bring them closer. It'll take you … many years, but there has to be a way, otherwise you'll be frustrated along the way, especially because most of these infrastructures for data capturing they have to be within the hospitals. And … so if you exclude them then … there won't be much progress in that regard."*

The general culture of distrust and lack of policy around keeping and sharing of electronic health records, even between different departments or research units that belong to the same institution, means that requests for access to data is fraught with bureaucratic and procedural obstacles, which impacts the ability of especially students to perform clinical or translational research:

> *Informant5 28:36 "they're the ones then who would have that interest in patient records. And the way that they gain access to that information is they have to go through the normal process. The HREC (Human Research Ethics Committee). But they also then have to go through another committee on the hospital side. And once they have cleared with the HREC, they then go through that channel, which will then grant them access to patient records." Informant5 31:33 "because you can waste a full year trying to go through one hurdle (to) the next."*
>
> *Informant5 32:13 "So .. I certainly think if in the streamlining of certain process, and especially for students, and it's even more heartbreaking when it's students going through that because … you need that to complete your degree"*

> *Informant14 39:32 "One of the most important things to clear away would be the NHLS politics. … it's trying to understand … what's going on there and trying to find a better way for dealing with access to information requests from academia and elsewhere to the NHLS's database. You know, to try and depoliticize it"*

The lack of integration between government and university information systems extends to physical infrastructure as well, leading to installation of parallel infrastructure in some areas and a complete lack of coverage in others:

> *Informant8 29:47 "But … why hasn't the university invested in this? Or government for that matter as well? I mean, it's so sad. Government's also put in the entire network to have Wi-Fi in in many places, but they don't make it (available). They haven't switched it on. It's not available to people, which is such a waste of money … and why the two systems, the Gauteng department of Health and the university systems don't basically talk to each other is also crazy, … we don't have to have duplication of costs and so on. …they need to talk to each other. If that could happen, … that would help us I think in terms of quickly rapidly getting access of Wi-Fi to people."*

> *Informant11 03:37 "And there's been a long standing problem for decades that the Wits and NHLS networks don't talk to each other. … the NHLS has*

some sort of firewall and … we are unable to access Wits sites through NHLS. And when we speak to Wits they claim it's incredibly difficult. I think it's easier to solve COVID, than to get the Wits ICT department to engage with the NHLS to get us access to the Wits network. And when you speak to the NHLS, the NHLS is an instrument of government, so it's like speaking to the Department of Home Affairs or the Departments of Water. You really get the run around, but Wits has really shown no interest in trying to solve the problem for us"

As discussed in section 2.4.5, the lack of availability of infrastructure for networking or capturing of electronic data is a significant barrier to both implementation and adoption.

2.4.5 Implementation Barriers That Affect Adoption: Network Infrastructure and Data Capture Devices

Table 2.6. Summary of the theme "Network infrastructure and data capture devices: how am I supposed to do this without a tablet and Wi-Fi?" and associated codes

Domain: Barriers	
Theme: Network infrastructure and capture devices – how am I supposed to do this without a tablet and Wi-Fi?	
Codes:	
Networking	Some rural campuses and public health facilities have no internet connectivity or have isolated LAN points but no wireless access. Broadband data costs are high in SA
Point of capture devices	Some rural campuses and public health facilities do not have computers or data capture devices. Where devices are provided, high rates of theft and poor maintenance are a concern. Bring your own device policies not compatible with low-wage earners like data capturers

When it comes to barriers, some informants identify lack of access to electronic devices and networking infrastructure as the most significant obstacle to adoption of EDC systems (Table 2.6).

Informant8 27:04 "So the biggest constraint, and I'm sure you'll hear it from all the others heads as well. The biggest constraint is just actually we don't have a very good infrastructure to do that right? And by that I mean that if you go to the (hospital), if I'm talking about the clinical, those spaces, so the (OWN

HOSPITAL NAME) is like an exception in that we've got Wi-Fi here, we are an exception. The rest of hospitals, even as big as Bara, … they've got internet connectivity in a few offices, academic offices. But throughout the campus of Bara, that huge campus that is the biggest hospital under the… university, there isn't Wi-Fi, which is in 2021? I mean, that's ridiculous. We had Wi-Fi here at (OWN HOSPITAL) since 2016 or 17 when we had the new building built. It did cost us money, but in the long run it … was well worth it. What we paid. We had to pay from research funding. So I think when you go to the clinical departments the one thing they'll complain about is that there isn't the connectivity that you'd want for people to enter … Obviously the hardware that the university doesn't quite put in, … you depend on an individual's personal computers and laptops … so that makes it also harder because you need to have that infrastructure in place and say … this is the infrastructure. It's there. The computers are there, it's networked. … And you need Wi-Fi, because if you're going to be collecting information you can't be running back …into your office to put it in, you need to do it at the bedside. You need to do it everywhere and so that, I think, is our biggest challenge."

Informant7 25:53: "So there are a lot of innovations coming out of 21st century learning for example. And we just don't have the hardware and the data systems to support that, so I think that's a huge need. If we're really going to seriously take on online learning and … data management in a big way, then we need the … support structure for it and I think that's important and I think the university is aware of that, but ... I think that the discussions with big industry players needs to happen so that … we shouldn't even pay for data. It should be a human right now. I think it should be something that everybody is taxed on and available. Even to my granny … in the village"

A few expressed intense frustration and disappointment that what they perceive as a basic need for performing their occupational duties were not being met. In fact, one informant described the disconnect between the university's strategic vision and reality of its employees' access to basic infrastructure as a form of madness:

Informant11 31:40 "And Wits is writing its strategic vision now, right? … it's vision beyond 2023, and it's all about … the moon shot, embracing 4IR, … embracing the digital revolution, imagining the University of the Future. But you cannot get network to 100% of your researchers. Should that not be a fundamental thing? Like as I talked to you now, I'm using my cell phone, right? And my computer is connected to my cell phone because if we do Teams on the NHLS network it is so slow it will freeze and you will have to log on six times. And so I just I go and I buy 2 gigs of data every week"

Informant11 32:49 “So … I think if the university wants to say it's embracing the digital revolution, I think it should stop ignoring the fundamentals, and the fundamentals is that this needs to be available. You can do electronic capture if you give somebody an iPad, but if you still give them a piece of paper and say, embrace the digital revolution, like it's a sign of madness, right?”

Additionally, lack of reliable electricity supply and a high rate of theft or damage to mobile devices make electronic data capture in the field an expensive and effort-intensive practice.

Informant2 14:15 “It'll be perhaps things like access to data or Wi-Fi. If there's no connection, what actually happens? Does my work pile up, or I can use the system even when it's offline and there's no access to electricity? And also with issues like … security. What happens if this the iPad, the device that I'm using, gets stolen under my watch while I'm on call or it falls … am I supposed to pay for it? Am I liable?”

Informant11 26:54 “The second is … especially in our peripheral sites … things like … where are we going to charge this thing? There actually isn’t any power in this room where we do…recruitment. We collect sputums and things outside. … if this thing goes flat what we do? So there’re … some operational issues which are not difficult to overcome, but they are there”

Informant13 39:06 “Currently we have … maybe 250 members of staff that are going out every day into the field, so that's … 200 a day tablets that you are sending out. You need to find a place where you are gonna charge them overnight…and also just making sure that you are tracking the equipment itself. You need good systems. Otherwise today you have 250 tablets. After a week you are left with 200”

2.4.6 User Barriers to Adoption: Fear of Change, Fear of Technology

Table 2.7. Summary of the theme “Fear: Change and technology is scary, and we already feel overwhelmed and under-resourced as it is” and associated codes.

Domain: Barriers	
Theme: Fear: Change and technology is scary, and we already feel overwhelmed and under-resourced as it is.	
Codes:	
Technology anxiety	Fearful resistance to technology. Perception that computing devices and data capture systems require “special IT skills” to

	operate. Linked to perception of differences in generational technology literacy or access to technology during childhood.
Fear of change	General anxiety or emotional resistance to changing from what is familiar, not just relating to the introduction of technology.

Several informants mentioned that fear around changing processes in general, and introduction of new technology in particular, were barriers to voluntary adoption (Table 2.7).

> *Informant11 26:14 "I don't actually believe it's a literacy issue. It's actually a fear issue that that people know how to use their smart phones, … but when you present them with this iPad, and you say, what you've been doing in paper now you do it like this. There's just an anxiety associated with the adoption, and I just think that that's all it is. It doesn't have to do with literacy, competence or anything, it's just the anxiety"*
>
> *Informant11 34:36 "I feel … there is this anxiety associated with digital and it has nothing to do with literacy or competence, right? I just feel like … there's a large group of people who are intimidated by this … technology and really, we need to bring everyone to a space where they comfortable…"*

> *Informant4 29:27 "especially if a unit, has been using … one system of doing things. That they kind of just adopt for every project. Changing that whole system is very scary. … nobody wants to change just for fear of things that could go wrong. I guess change in any circumstances scary, so that would be … just a hesitancy to change."*

A number of informants thought that fear of new technology was particularly prominent amongst older adopters, or those who did not have access to information technology devices while growing up:

> *Informant2 13:55 "So in my view, it will obviously be time, people may feel we don't have time. Number two it'll be the lack of computer skills, other people who are probably a little bit older. They may feel we're a bit technologically challenged and therefore we not eager to do this"*

> *Informant6 07:45 "in my opinion I think it's generational. I think …my younger colleagues or peers within the school, … they're more tech savvy, you know? So I was taught on excel, … my development started with that, so I'm more comfortable with it. …. So I think … there is an aspect around age … and when we were exposed to the (system) and what was the foundation basically"*

Fear is also repeatedly mentioned in relation to time and effort expenditure, and is discussed in the next section (Section 2.4.7).

2.4.7 User Barriers to Adoption: Ease of Use and the Misalignment of Time/Effort and Motivation

The ease of use of a data capture instrument is mentioned by most of our informants as a barrier (or enabler) of adoption (Table 2.8).

Table 2.8. Summary of the theme “Ease of Use: Misalignment of time/effort and motivation. When we say ‘too difficult’ we mean ‘not worth the effort’” and associated codes.

Domain: Barriers	
Theme: Ease of Use: Misalignment of time/effort and motivation. When we say ‘too difficult’ we mean ‘not worth the effort’	
Codes:	
Time and effort	Reluctance or a sense of being overwhelmed is expressed when speaking about the time and effort it takes to learn how to use a new technology, using technology takes longer than the process it replaces. This resistance is reduced if the user has support and directly benefits from the system
Instrument complexity	The complexity, intuitiveness, or ease of using a data capture system is cited by most informants as a reason to adopt/abandon. The level of “ease” seems heavily influenced by the users’ perception of benefits/relevance to themselves. The less a user stands to gain from a system, the simpler their interaction with the system must be
Motivation	Motivation influences users’ perception of how easy it is to use. Researchers or managers have an interest in having access to aggregate data in order to perform their duties, and are more highly motivated to adopt electronic data capture. Clinicians and nurses are often tasked with capturing electronic patient information, but doing so is not perceived to benefit them in the performance of their primary duty to deliver clinical services to patients (or in some cases, it is perceived to detract from their primary duty).

Both in response to the question “what are the barriers to EDC adoption?” and while they were talking about their experiences with electronic data collection systems,

informants cited instruments that were “too hard” or “took too long” to use as reasons why they abandoned a particular system.

> *Informant1 33:50 “… I think the bottom line for me is ease of use would be the driver and obstacles or not being user friendly would be the barrier.”*

> *Informant5 22:59 “I felt the ease of use of the others … outweighed that of using REDCap such that if I compared the difficulties, I would have to go through with REDCap it … didn't seem justifiable, and … we always try to take the easier route if we can get the same outcome.”*
>
> *Informant5 23:35 “I guess, one, it was the ease of use, two, I had limited time to really get to understand it, but the others were fairly easy to grasp for me. I recall that with the Microsoft one it took me 3 minutes and the person was just telling me this is what you do. Thought it was so easy. 5 minutes for the Google one and I thought it took me 3 minutes with the other …. Now REDCap I'm having to try understand this for over 30 minutes. I don't have the time, you know. … Yeah, so time constraints is another factor”*

> *Informant7 21:27 “… one person described something to me. She said it's like being in a very little ship in the middle of a hurricane, and you have been tossed and turned, and you are working until late hours because you first have to learn, then do it, then deliver, all in that space.”*
>
> *Informant7 22:24: “I am so exhausted with the number of new things that come up because I just learn one thing, and then I've got to add this, or they've changed the platform … and I don't have time to learn that. Let me settle in first.”*

The perception of how easy to use a system is seems to be heavily influenced by their level of motivation to use the system, which in turn depends on whether the individual thinks that the system will add value for them. Value could be provided through access to the downstream benefits like aggregate data and reporting tools, or by making the performance of their work easier and simpler.

> *Informant9 17:48 “What makes me spend time putting data into a computer is interest, and … whether that's my financial interests or whether I have this wish to understand what's happening around COVID … or … whether I follow the rainfall pattern in (SUBURB) in Johannesburg. ... But I mean, … there has to be something that you bring out.”*

> *Informant7 15:56 "I think … the very nature of Wits is very technocratic. So people pay attention to their area of expertise. And they don't connect it to the data. So they find data as an added burden, except where it inputs into their technical area of expertise. So I think that's one reason. The other one is people are just poor planners, some of them. And they prioritize other things. … and you see it, a person who's a good planner, and works and makes sure that they deliver. They will always give you data no matter how busy they are, and then other people just lack the interest really."*

As we saw in the theme about downstream benefits (section 2.4.2), researchers are highly motivated to use EDC systems because it provides a great deal of value to them. However, the time and effort to capture clinical information into electronic data collection systems often fall on doctors or nurses, who are already over-worked just to meet the demand for clinical service delivery.

> *Informant8 28:47 "the second … is the lack of dedicated data capturers, which is obviously a big (one). Cause we're relying on people to just fill it in like the doctors and nurses... There isn't a great motivation … to do this and so they won't do it very well. And half-heartedly and grudgingly. And so it doesn't become good data. You need data capturers to enter it and you also need data cleaning and so on"*

> *Informant14 13:50 "I recognize the importance of collecting data, but I also recognize that the people asking for it never feed back, and secondly they don't understand how much work it is and they're asking the most expensive, it's not just that the busiest, but also the most expensive people to collect."*

The lack of time and motivation to enter data by clinical staff is exacerbated by the lack of integration discussed previously (section 2.4.4). If electronic health record systems were integrated with ordering and prescribing processes to generate secondary data, or replaced paper summaries instead of existing in parallel with them, they would provide efficiency gains to the individuals who are being asked to enter data rather than adding to their workload.

2.4.8 Enablers of Adoption: Promotion and Support Increases Familiarity, Reduces Fear and Demonstrates Benefits

In both voluntary and involuntary EDC adoption examples, informants spoke about strategies to overcome fear as one of the major ways an institution could facilitate acceptance by users (Table 2.9).

Table 2.9. Summary of the theme “Promotion and support increases familiarity, reduces fear and demonstrate benefits” and associated codes.

Domain: Enablers	
Theme: Promotion and support increases familiarity, reduces fear and demonstrate benefits	
Codes:	
Bridgers and champions	Early adopters within the organization provide evidence that the electronic data capture is worthwhile investing time and effort in. Citing technology used to produce reports or research outputs during academic or leadership meetings important
Promotion campaigns	Top-down support and commitment to preferred electronic data capture tools must be regular and widely signalled
Technical support	There must be knowledgeable, contactable “go-to” individual/team who can answer questions, troubleshoot or provide expert consultation services
Familiarity	Users keep using the systems that they are familiar with, either because they were taught on it in school or university or because the department they work at is already using it

Promotion campaigns, testimonials from trusted colleagues and access to official and unofficial ‘go-to’ individuals were some of the approaches our informants thought were most helpful. We think that these social influence strategies help individuals evaluate the likelihood that the system will be a worthwhile investment of their effort, both by demonstrating how the system has helped solved similar needs of their colleagues, and by signalling organizational commitment to a certain product.:

> *Informant2 15:20 “I think there will have to be, obviously, a campaign. … before you even launch the software. It'll just advertise and market the benefits and … with an intention of making people aware that…we are all aware of the limitations of… moving to an electronic based system but at the same time, these are the benefits for the doctor, for the … patients and also for the community or country as in general. So there has to be people that go,*

maybe from hospital to hospital talking about this, and highlighting why it's so important to just transition from where we are to where we going"

Informant12 47:58 "we just had our research day last week, and … I wonder whether people actually even mentioned it, but I certainly think there is this idea of, … there are early adopters, people who … get excited by something which they read about or hear about or whatever, and then take it on board quite quickly. And then there are others who need a bit more convincing. And I really think that only way that somebody can be convinced is really to actually appreciate the benefit. So you've got to almost have the experience of somebody who you trust and who you respect, having had the experience and saying … wow, this really made a difference and I think that people would adopt it more."

Informant7 24:13 "… with the increased a turnover of technology, you then need somebody to come and say, … this is new, just add this and that and then your work is facilitated. Otherwise it just becomes a pain and from that perspective the university must decide on the learning management system and stick to it, irrespective of its problems, because I'm absolutely fed up with starting with Sakai, we had Moodle, then you know, now it's a Canvas. We better stick to canvas, otherwise they're going to irritate the hell out of all of us."

Informants also cited having access to a 'go-to' person that would 'hold their hand' as a critical factor that enabled them during an EDC adoption process. A number of them describe feeling very overwhelmed during the process until they reached out to an individual who could guide and reassure them.

Informant10 31:00 "and there needs to be an avenue where when people are frustrated and they're just, … can't figure out how to get it done, that … there's someone that they can go to who will say, don't worry, I'll hold your hand through this process and … we'll figure it out together because I do think that that that's a big part of it. People don't like change, they're afraid of change ... They're very reticent to try something new, so if there's someone there who will hold your hand through the process and show you that it's not as bad or as difficult as you think it is I think that is a big help".

Informant4 30:22 "I think having somebody with extensive experience in …a new platform or a new way of doing things … helps. And (this) would probably be kind of the only way that we might … make these big changes. … having

someone say OK, I've done that before, I've used that before, I can run with this, yeah?"

Informant6 16:13 "I probably wouldn't have gone with that system to be honest with you ... if I didn't have a physical individual that I could speak to and also complain to and also get advice on how the system, and reassurance, that look it is working. …. So I do think that, yes, that physical interaction of an individual is really quite significant."

The supportive resource also acts as a gateway to self-efficacy and learning activities, as some informants describe gaining the confidence to resolve their own queries after initially interacting with a designated go-to person:

Informant6 30:25 "… for example the language thing. With this I think it was HTML coding or something that you were using in there. … so after our second meeting I had another problem. … but I just Googled HTML coding or something around that and I was able to figure out the issue immediately. … but I didn't know it was that easy."

As we discuss further in the theme about training and capacitation (section 2.4.10), the availability of training resources complements support strategies in reducing fear, while at the same time building capacity and skills at an institution.

2.4.9 Enablers of adoption: Configurability and empowerment

Table 2.10. Summary of the theme "Systems that add value and a sense of control/ empowerment increase motivation" and associated codes

Domain: Enablers	
Theme: Systems that add value and a sense of control/ empowerment increase motivation	
Codes:	
Configurability	Systems that are highly configurable results in tools that are adapted to match processes more closely, as well as giving users a sense of control and engagement
Instrument re-use	Systems that are generalisable/configurable will probably be used over and over for new/emerging needs, resulting in an increased return on effort invested while learning/adopting
Data access and re-use	Systems that give its users access to aggregate data and reporting tools result in more motivated users as well as unlocking the value of the data through re-use.

Some informants discussing voluntary adoption scenarios describe EDC systems that are highly configurable and includes data reporting and visualization tools as attractive to them (Table 2.10).

> *Informant4 03:17 "I think what happens when you are a statistician is, you're the one analysing the data, so everything that influences the quality of the data up to when you're ready to analyse it is very important. Anything from study design and how you collect your data, what instruments you used to collect your data. Even the operational process of how you collect the data is going to affect it so. I think that's how in the unit I got roped into more of a lot of data management from early study design or throughout the study, and even after the study is completed."*
>
> *Informant4 04:12 "You know…that in the long run, how the data is going to be used so there's … a lot of little tweaks you can do at the design stage that will just make your life a lot easier and will just make things run a lot more efficiently."*

As illustrated by the next excerpt, informants who used a highly configurable EDC like REDCap preferred it over other systems that provide less access and control:

> *Informant12 15:15 "No like it actually, I feel like I have much more control over it. I can't even tell you, we're on version 17 of our (PROJECT NAME) questionnaire, and we've had so many problems. And the problem is that I can't go in and fix it. So we relying on somebody who we've outsourced to, and that's my frustration, because all my REDCap projects I control, so I can make changes, I can … sort of like test it. I can do all of those sorts of things and check the logics at … the …skip patterns and all of that."*

Implementing EDC systems that offer a great deal of customization can be a good investment for an institution, as a wide array of needs can be met with one product, and the time users spend developing skills and familiarity can be re-used.

> *Informant8 06:10: "what attracts me most to it then and even now is the ease at which one can create the form. So it's a very… user friendly system that's been designed where … I can create a form within minutes … because they've got all these options of the fields so to … navigate around it. And … to show it to someone and say… you could do a form within an hour, they'll be amazed at how many options they have and … how simple it is to … put those various fields in and so that's …the biggest attraction for me"*

Informant8 06:58 "The other part of it is the ease at which one can draw reports 'cause it allows you to go and have a look at a database very easily and also draw down an Excel or CSV file of the data. So that definitely makes it …very attractive."

Even when an EDC system is designed to make advanced design, configuration, and analysis tasks intuitive to its users, these features often require at least some training or specialist skills to use correctly. The role of training resources and capacity building is discussed in the next theme (section 2.4.10).

2.4.10 Enablers of Adoption: Capacitation and Skills Development

The availability of training resources can play two roles in easing EDC adoption: firstly, it provides a sense of comfort to prospective users that helps to overcome the fear of unfamiliar systems and processes, and secondly it enhances what users can achieve with the system. Additionally, by creating dedicated positions in an institution that receive specialised training and focuses on a specific aspect of the information lifecycle, higher quality data and outputs are produced (Table 2.11).

Table 2.11. Summary of the theme "Capacitation: Skills and human resource development maximize benefits of using EDC" and associated codes.

Domain: Enablers	
Theme: Capacitation and empowerment: Skills and human resource development maximize efficacy and let users feel empowered	
Codes:	
Training resources	On-demand resources like tutorial videos and documentation sites allow users to resolve issues on their own, increase their skills and lead to a greater sense of control and empowerment. Facilitated/scheduled formal training can help reduce fear through interacting with an expert, but is less useful if it doesn't coincide with actual adoption.
Dedicated data roles	Having posts dedicated to capture, quality management or analysis of electronic data provide quality and efficacy gains for research projects and operational processes, while also reducing the burden on nurses and clinicians.
Formal capacitation requirement	Individuals often feel that they do not have time to learn new skills. By making skills development a formal deliverable in employees'/students' contractual obligations, both motivation and protected time is provided to engage with training resources

Our informants expressed different preferences when it came to the mode of delivery of training resources, depending on their own needs and at which level they engage with an EDC system. Shorter, more targeted, and on-demand resources like tutorial videos are attractive when the user has a specific question or task that they need to complete, and answers are available without having to wait for a scheduled training session.

> *Informant1 31:07 "maybe some how to sessions, maybe even just webinars or things like that …would be great. Actually, where you can look at it in your own time and you don't have to … go and attend a three-day course … That's what's great, for example, I use STATA for statistical analysis. And I tell you there's nothing that you cannot get a YouTube video on to explain what to do in STATA for a particular test, it's amazing. They have a designated YouTube channel for their … training"*

> *Informant 2 21:39 "I think for clinical workflow because the instances were … you, as a doctor, you under a lot of pressure and you need to find the answers almost immediately and the person, perhaps that is usually in charge of the system, is not around and it's an emergency. You'll want to be… capable and able, … just doing the basics and retrieving the information. Honestly, for myself, I believe in empowering people, and just giving them the resources."*

Other informants preferred more formal workshops introduced as a routine part of undergraduate training or new employee induction as a strategy to both capacitate and familiarize future researchers and clinicians with regards to using EDC systems.

> *Informant10 31:33 "but I do also think that there's a time element to it… because as I say, what we found is that people are really reluctant because they think … it's yet another thing on their list of tasks to do that they've got to complete and they just don't have the time to do it. … So if they … along with offering this training and support, there's got to be some way of … offering time off, protected time, for people to be able to adopt those processes until it becomes integral to your workflow and it's … just part of what you do and then it's easy, then … it's just part of your day"*

> *Informant7 17:41 "If I think how I started at Wits, I hit the ground running. And somehow any capacitation has to be outside working hours or in in my own time and so on. And the tools. It's like sending me to the garden and saying make your own fork and spade while you dig with your hands. And I think that the university should have a very structured induction process for lecturers*

and even the professional staff where they say you have to get this course done to competency. At least basic competency. If that had been done for me I think and the time is put aside, it's not somewhere in your lecturing from eight to five find the time to learn how to use X"

Informant12 48:50 "But I do think that integrating it into training is imperative. So what we're doing in our programs, … where students actually develop skills, because at the end of the day, one assumes that … they will be future researchers and academics and … they understand the benefit."
Informant12 31:08 "But now everybody does REDCap … within our student body, and we actually teach them REDCap now as well as part of their coursework. So they learn it in a couple of different ways, but if they're doing (COURSE NAME) they actually do REDCap as … one of the sections within a course, … and they have to develop a questionnaire on REDCap for an assessment so … we're really trying to promote … the use of electronic data capture as a way to ensure better quality data collection. And the fact that it can be … interview administered or it can be self administered … makes it really usable across any study, regardless of whether it's community based or whether it's … with health care providers or … whoever it's with."

Informants also discussed the need for addition capacity through having specialized positions that are dedicated to data capture, quality control, aggregation, and analysis:

Informant13 21:10 "… before any study starts, … depends also on how complex this study is. Like for this surveillance we will train them for … three weeks to a month. And also these other specialized studies we also train them maybe two weeks or three weeks or even a month, depending on … the procedures that are involved in these studies. Because some of these studies, they involve both administering the questionnaires but also collecting blood samples. So … we have to do the consenting process is also electronic, so we have to go through all the different components of … this study with them and make sure that they …have mastered the study and we are all asking the questions, in the same way, so that if we see differences in their responses, it's not… because of differences in the in the way the interviewers have asked the questions."

Informant1 20:07 "…to have everything together like a research nurse, so …on top of all the clinical and demographic … data capture, making sure all is there, a technician to immediately … process samples. So yeah, just a team working together, … even if we can have a designated data capturer or two …just … for departments that are doing a lot of studies. So to have that

person at Bara, and to have that person at Charlotte, so we know the data is being captured and if anything is missing, this person is going to follow up."

Informant11 35:15 "Then the third is I feel like we're only tapping into maybe 1 to 2% of the potential of our data, because once you have this data the way you data mine and you use big data, because very soon if we all adopt this, this this electronic approach, very soon we'll have a lot of big data. It won't be in filing cabinets, it will now be big data and I think how you ask questions of that data and how you interrogate it. I think actually having formal courses and formal programs. Not everyone is interested in it, so I'm not saying we should do it for everyone. But … I know there's a discussion about a data science institute or something like that, but I think developing more data driven initiatives, the university can think about how to resource those."

2.5 Discussion and Conclusions

As part of an institution that supports various EDC systems, we set out to better understand the drivers, barriers and enablers affecting end-user acceptance and adoption at our institution. Through inductive thematic analysis of semi-structured interviews with fourteen key informants, we identified a number of factors that affect adoption and must be considered when choosing appropriate EDC systems and crafting implementation and support strategies for our environment.

It quickly became apparent that the way drivers, enablers and barriers relate to each other at our university are different when adoption is voluntary than when it occurs through institutional mandate. Voluntary adoption is driven by factors like perceived efficacy gains, access to and secondary use of aggregated data, reduced turnaround times and entry error reduction. These "attracting" factors remain important even when the main driver is by institutional mandate, when they serve as enablers rather than drivers. In either scenario, prospective users have an almost reflexive resistance (and in many cases fear) of change, often defensively expressed as a lack of time or ability on their side. This resistance is ameliorated when supportive resources are available to reassure them that mastery is possible, help is available when needed, and when the institution consistently signals that they have committed to a specific product and promotes the evidence of adoption benefits that balance the effort and discomfort of changing.

The availability of training appears to be important to most of our informants, but we see a divergence of viewpoints between voluntary and mandated adoption, as well as the relationship between the user and the system. Voluntary users are attracted by advanced features, configurability, reporting, and analysis capabilities, some of which require specialised training. On the other hand, some individuals who capture data electronically because of mandates alone are not motivated by the downstream benefits, and in those cases the main enabler is that the system must be as effortless and intuitive as possible, to the point where training requirements should be minimal.

Some informants expressed a preference for targeted and on demand training resources like YouTube videos, which can be accessed to address a specific need as and when the user requires. Others pointed out that formal, facilitated workshops can be supportive to those that may be fearful or unsure if a system will benefit them. Several informants described taking time off to upskill themselves outside of the working environment, and suggested that by including EDC training as part of student coursework or new employee induction processes, prospective users are both given basic competency and familiarized early on, hopefully before they adopt less desirable alternatives.

Most of our informants recognized that the full benefits of a system is unlocked when dedicated, specialised roles are created for the capture, quality control and analysis of data. Adequate human resourcing for data roles remains out of reach for many departments though, unless budgets have been made available through external research funding. Other barriers that need to be addressed at an institutional level include a lack of reliable networking infrastructure at all sites where the University operates, and data interoperability/sharing policies with Government to leverage and aggregate all possible data generation processes for the benefit of patient care and research alike.

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PART THREE - REDCap GROWTH AND ADOPTION SUPPORT STRATEGIES

Original Paper

Maré IA, Kramer B, Hazelhurst S, Nhlapho MD, Zent R, Harris PA, Klipin MJ

3.1 Electronic Data Capture System (REDCap) for Healthcare Research and Training in a Resource-Constrained Environment: Technology Adoption Case Study

3.2 Abstract

3.2.1 Background:

Electronic data capture (EDC) in academic healthcare organizations provides an opportunity for the management, aggregation and secondary use of research and clinical data. It is especially important in resource constrained environments such as the South African public healthcare sector, where paper records are still the main form of clinical record-keeping.

3.2.2 Objective:

We describe the strategies followed by the Faculty of Health Sciences, University of the Witwatersrand (Wits FHS), during the period of 2013-2021 to overcome resistance and encourage adoption of the Research Electronic Data Capture (REDCap) system by academic and clinical staff. REDCap has found wide use in varying domains including clinical studies, research projects and administrative, financial and human resource applications. Given REDCap's global footprint in more than 5 000 institutions worldwide and potential for future growth, the strategies followed by the Wits FHS to support users and encourage adoption may be of interest to others utilizing the system, particularly in resource-constrained setting

3.2.3 Methods:

The strategies to support users and encourage adoption included: 1) Top-down organizational support; 2) Secure and reliable application, hosting infrastructure, and systems administration 3) An enabling and accessible REDCap support team 4)

Regular hands-on training workshops covering data collection instrument design and use of REDCap; 5) Annual local symposia to promote networking and awareness of all the latest software features and best practices for using them 6) Participation in REDCap Consortium activities; and 7) Regular and ongoing mentorship from members of Vanderbilt University Medical Center.

3.2.4 Results:

During the period 2013-2021, utilization of the REDCap EDC system by individuals in the Wits FHS increased from 129 active user accounts in 2013 to 3 447 active user accounts in 2021. The number of REDCap projects numbered 149 in 2013 and increased to 12 865 in 2021. REDCap at Wits also supported various publications and research outputs including journal articles and postgraduate monographs. As of 2020, a total of 233 journal articles and 87 postgraduate monographs acknowledged the use of the Wits REDCap system.

3.2.5 Conclusions:

By providing reliable infrastructure and accessible support resources, we were able to successfully implement and grow the REDCap electronic data capture system at the Wits FHS and its associated academic medical centers. We believe that the increase in use of REDCap was driven by offering a dependable, secure service with a strong end-user training and support model. These support strategies may be applied by other academic and healthcare organizations in resource-constrained environments planning to implement EDC technology**.**

3.2.6 Keywords: electronic data capture; implementation science; REDCap; biomedical informatics; South Africa;

3.3 Introduction

3.3.1 Background

Challenges to EDC implementation in healthcare

Electronic data capture (EDC) and management is a vital part of the administrative process in almost all industries, but despite its many advantages, adoption in the healthcare research and clinical service delivery domains has lagged behind other industries [1–13]. Major obstacles include cost, lack of policy at management level, implementation failure and data security concerns [1–7]. Additionally, research information applications developed specifically for one environment usually require significant resources and support to function in another environment, as the technology, support, security, and privacy needs are often different [5,8–10]. Many institutions within sub-Saharan Africa and other low and middle-income countries lack the technical resources to support information systems for healthcare research and clinical service delivery [11–13]. Moreover, power and network infrastructure may be unreliable [11–13].

Even with the necessary organizational and infrastructure support, the success of EDC software applications is not guaranteed [4,5,14]. The lack of domain knowledge in resource-constrained environments such as sub-Saharan Africa has hampered implementing EDC technologies [11]. There is often a paucity of individuals with the necessary clinical/academic and information technology (IT) skills required to support critical healthcare data management systems [11]. Field workers and clinician scientists, while highly skilled and valued in their domain, may not be well versed in technology for the capture, storage, and transmission of health data [4–7].

Once infrastructure and skills resourcing issues have been overcome, familiarity with deeply ingrained systems and processes at every level of the research enterprise is a natural cause for resistance to change [1,4–7,15–18]. This includes, for example, the replacement of hard-copy files with electronic data collection instruments for clinical research informatics. Strategies to obviate the resistance to implementation of new technology include demonstrating trustworthiness and benefits of the technology, while at the same time easing the transition with access to appropriate training and support [1,5–7,16,17].

The state of EDC at Wits FHS before REDCap

The University of the Witwatersrand (Wits) is a research-intensive university based in the metropolitan area of Johannesburg, South Africa, an upper middle-income environment [19]. The Wits Faculty of Health Sciences (FHS) operates within a healthcare system weakened by socio-political and historical issues and strained by an ongoing quadruple burden of disease [12,20,21]. Setting up systems to support academics in their clinical and research activities is subject to budget constraints and by the geographical distribution of the approximately 2 500 health sciences staff and 7 000 students, spread over three discrete academic teaching platforms and many field sites in both urban and rural regions [22,23].

Before the implementation of the centrally supported EDC system at the Wits FHS and the associated research entities in 2012, electronic data management services were fragmentated, inconsistent and variable. Individuals and research entities were using local devices and legacy systems familiar to them, or choosing new products to implement based only on their own needs, abilities and budget. This fragmentation was not desirable from an organizational perspective, as the datasets were isolated, the financial and human resources used for procurement and management were diluted and the security and privacy of data could not be guaranteed [5,9,10].

During the same period, most of the patient health record data being collected at Wits FHS-related medical centers were paper-based. Clinical staff were burdened by service delivery demands [20], and were restricted in their time available for research or data capture [24]. Where electronic research data collection instruments were used, they ranged from simple spreadsheets such as Microsoft Excel to enterprise-wide data management systems. At the time, there were no preferred instruments within the Wits FHS, and the safety, security and privacy of the data was at the discretion of individual researchers. There was little standardization of metadata or clinical coding systems, and as a result interoperability and secondary analysis of data was rare. This impacted patient care and limited the dissemination of important knowledge gained in treating various infectious diseases and diseases of lifestyle which continue to burden the South African healthcare system [12,20,21].

3.3.2 Prior Work – Implementation of REDCap at Wits FHS (2012-2013)

In 2012, as part of a process to strengthen research support, training and outputs [8,24], the Wits FHS implemented REDCap, a web-based EDC tool created by informaticists at the Vanderbilt University Medical Center (VUMC) in Nashville, Tennessee, USA [8,25]. One of the Wits FHS's strategic goals was to unify and systematize healthcare and research data collection within the Wits FHS [8]. REDCap was an attractive option due to its freeware licensing model for non-commercial use and large international support community [14,25]. The decision to implement REDCap was also supported by an existing diaspora relationship between Wits FHS and REDCap's parent organization, VUMC [26].

The strategies employed to install REDCap and overcome the initial implementation barriers within the Wits FHS has been presented previously [8]. The crucial factors highlighted in the article were support from Wits FHS management and the allocation of a modest budget for hosting infrastructure, systems administration, and recruitment of personnel from existing staff for end-user support. Support staff were initially allocated part-time on a sliding scale of need, which allowed dedicated end user support while limiting costs. The hardware costs were limited to servers and security certificates, which were housed in existing university data centers. Four months after implementation, the number of REDCap users at Wits FHS was 81, and after 12 months it had increased to 140. The total costs to provide a functional REDCap platform for the first year was less than $9 000 [8].

3.3.3 Goal of This Study

EDC implementation projects often fail after the initial deployment due to resistance and lack of adoption by end-users, even when leadership, infrastructure and human resources are mobilized successfully [1,2,5,9,13,18]. The Wits FHS employed various strategies to engage and support end-user to overcome these challenges, and the period 2013-2021 was characterized by sustained – sometimes exponential – growth in the demand for REDCap accounts and support services. This paper discusses the methods that helped to overcome barriers to adoption, as we believe that these strategies may be applied in other low to medium-income and resource constrained environments where EDC implementation and adoption is subject to

similar challenges. We measured the growth in REDCap usage by increases in user accounts, projects, publication metrics in the Wits FHS.

3.4 Methods

3.4.1 Adoption Support Strategies

Hosting and Systems Administration

To gain the trust of users, reliability of the Wits REDCap system was paramount. The system was deployed on two virtual machines – one for the MySQL database and a second for the REDCap application – on a reliable Intel server with 64GB of RAM and considerable disk space. The Ubuntu LTS operating system version current at the time was used for both virtual host and physical machines. New hardware was introduced every 3-4 years, the cost implications when amortized over the life-span of the machine, were small. Older retired hardware was recycled for less critical work. Multiple levels of backup were employed. Daily backups of the database and uploaded files were kept on a separate machine. Thrice weekly copies of the virtual machine images were created and stored on a server on a different campus. No major hardware failures occurred in the period, but tests were performed to emulate recovery using the backed-up data to ensure that such would be possible in the event that the primary hardware failed. Nagios [27] was used to monitor system health and stability. The electricity supply in South Africa was periodically unreliable; however the server was placed in the University's data center with multiple backup power redundancies and physical security infrastructure. The REDCap application itself proved to be highly reliable, with regular bug fixes, security and functionality updates released by the VUMC developers. The human resource allocation dedicated to system administration from 2013 to 2019 was equal to approximately 0.05 of a full time equivalent (FTE).

In 2019 the load created by concurrent users and processes made it necessary to move from magnetic to solid state drives. From 2020 onwards, infrastructure and systems administration demands outgrew the existing resources. The Wits FHS REDCap system was moved from the University of the Witwatersrand data center to a leading South African cloud hosting provider (Teraco) [28]. Additional systems administration capacity from the Wits Health Consortium (WHC) [29], a wholly owned

subsidiary of Wits, was brought in to manage the cloud hosting environment, with continued guidance and leadership from the original systems administrator. The WHC infrastructure team use Arcserve [30] for daily snapshots of the virtual environment, with a separate backup every 1-3 days on a removable storage device for offsite storage. At the time of writing, the time spent on systems administration totals approximately 0.1 FTE.

End-User Support

The second crucial component of the Wits FHS implementation strategy was a dedicated ‘go-to’ individual to support end users, known as the REDCap administrator [8]. One of the most effective types of individuals to place in this role is referred to in the literature as a ‘technology bridger’ [2,9,31]. A bridger is an early adopter who has a deep understanding of the technology being implemented, as well as having the soft skills to teach and support others at their organization.

The implementation of technology is a form of change management, and by approaching end user support with an open-door policy and a culture of *psychological safety* (“a belief that one will not be punished or humiliated for speaking up with ideas, questions, concerns, or mistakes” [32]), the anxiety and resistance to change exhibited by end users is reduced (personal communications by Wits REDCap Administrator, July 2021).

By encouraging one-on-one consultations with the REDCap administrator in a relaxed and informal setting, new users felt safe to discuss their concerns or expose where they might have a lack of understanding. All email support and one-on-one consultations were provided at no cost. Over time, the need for additional project design and management services for larger and more complex projects became clear. To protect the REDCap administrator from users wanting to make use of the design service rather than engaging with the administrator to learn how to use the system on their own, an hourly fee was implemented for design services.

As the number of end users grew, so did the support and administrative needs (Table 1): Between 2013-2014, one part-time REDCap administrator (0.5 FTE) was adequate. This was increased to 1.0 FTE from 2014, and a second full time

administrator was added in 2016. Additional part-time REDCap administrators were added in 2021 in response to a large increase in system usage and currently totals about 2.2 FTEs on average.

Table 1. Number of REDCap Application administrator FTEs per year.

Year	REDCap Application Administrator FTEs
2013	0.5
2014	1.0
2015	1.0
2016	2.0
2017	2.0
2018	2.0
2019	2.0
2020	2.0
2021	2.2

Hands-On REDCap Training

The REDCap application has a number of built-in tutorial videos and extensive 'Help and FAQ' documentation. However, our experience showed that in addition to one-on-one consultations, the majority of late adopting end-users benefitted from in-person formal interactive instruction in the use of REDCap design tools. A series of sessions were offered during 2013, the content and format of which informed the creation of formal structured REDCap training workshops in 2014 and thereafter. While the workshops were well attended, a significant proportion were absentee reservations who did not attend. This prompted the introduction of a registration fee, which improved compliance and provided funds to contribute to the sustainability of the REDCap support team.

Initially a basic introduction to REDCap workshop was offered, but as users became more skilled, a more advanced workshop was added in 2015. Good design practices and standardization of metadata were encouraged, and the workshops also established an interpersonal relationship between the end-users and the REDCap administration team. A few groups, both within and external to Wits FHS requested on-demand REDCap training programs similar in content to the workshops. The

number of REDCap training workshops and attendees are summarized in Table 2 and Table 3, respectively.

Table 2. The number of REDCap workshops from 2014-2020, as recorded by online booking forms and attendance registers.

Workshop type	2014	2015	2016	2017	2018	2019	2020
Introductory workshops	2	6	6	7	5	5	5
Advanced workshops [a]	0	2	3	5	3	4	3
On-demand workshops	0	2	1	1	3	0	5
Total workshops per year	2	10	9	13	11	9	13

a. Prior to 2019, these workshops were referred to as 'intermediate' hands-on REDCap workshops. A significant proportion of novice users attempted the intermediate sessions and found the content and pace of the intermediate session beyond their capacity. We therefore changed the name to 'advanced' hands-on REDCap workshops and set up entry requirements in 2019 to emphasize that attendees had to have mastered the basics on their own or have attended an introductory session before attempting the advanced one.

Table 3. The number of REDCap attendees from 2014-2020, as recorded by online booking forms and attendance registers.

Type of attendee	2014	2015	2016	2017	2018	2019	2020
Wits FHS attendees	21	108	167	110	113	94	108
External attendees	9	38	45	80	25	16	43
Total attendees for each year	30	146	212	190	138	110	151

Each year, approximately five introductory and four advanced workshops were delivered, with an average of 19 and eight attendees at each workshop respectively. Step-by-step workshop manuals were also compiled iteratively over time and provided to attendees from 2017 onwards. A total of 977 individuals attended all workshops between 2014-2020. Seven hundred and twenty-one were Wits FHS affiliated, while 256 attendees were from external organizations. Fewer workshops were offered in 2018-2019, due to staffing constraints. From March 2020 onwards, workshops were shifted to a virtual (Zoom) platform due to COVID-19 restrictions on

in-person gatherings. The availability of online teaching resulted in an increase in on-demand workshops – five were held in 2020 compared to between one and three in previous years. We attribute this increase in part to the wider access inherent in the online format and partly due to the increased number of new users in 2020.

REDCap Consortium Participation

The 'REDCap Consortium' is a community of REDCap administrative and technical support staff from the academic, non-profit and government institutions that have adopted REDCap [14]. The REDCap Consortium represents a 'professional home' for many of the local REDCap research informatics leaders, and is a forum for enabling teams to share ideas, problems, and solutions related to the innovative use of REDCap [14]. Feedback and communication with the local administrators participating in the REDCap Consortium is a vital component of how REDCap program leaders understand unmet needs, socialize concepts for new features, and eventually prioritize new development. The voluntary participation in the REDCap Consortium is a very valuable investment for organizations [14,33]. Membership to the consortium gives partner organizations' REDCap administrators access to various networking and information sharing platforms, of which there are three main types: 1) Consortium calls, 2) conferences and symposia and 3) the REDCap Community forum. Between late 2013 and April 2020, the number of REDCap Consortium members from Africa and South Africa grew from 26 and 8 respectively to 261 and 175 respectively [8,34].

REDCap Consortium Calls

The REDCap software development team at VUMC hosts a weekly technical call, a forum to share news, updates and generally bring the REDCap developer and administrator community up to date with the latest REDCap features. Since 2016, VUMC also hosted two Eastern Hemisphere Partner consortium calls, at times that made them accessible to the Africa/Europe and the Australia/New Zealand/Japan regions, respectively. Various sub-committees have also formed within the REDCap Consortium, either based on common interest (software validation or development of training materials) or on shared geographical location and language (Hispanophone or Francophone committees). Some of these sub-committees also host regular calls relating to their specific domains. A locally hosted call for the African region was

added in 2018 through a collaboration between the REDCap Administrator of the Pan-African Bioinformatics Network for H3Africa, based at the University of Cape Town and the Wits REDCap team. Participation in these calls supports and develops REDCap administrators by keeping them up to date with the latest developments, enabling networking and exchange of ideas, as well as giving them a platform to connect directly with the REDCap software development team at VUMC.

Conferences and Symposia

The annual REDCapCon is a forum for REDCap administrators from different countries, institutions, and environments to meet, share experiences and create a support network. The opportunity to interact with international members forms the basis of a collective resource for information dissemination and problem solving within the global REDCap community. Participation in the annual REDCapCon, a forum for REDCap administrators to meet, share experiences and create a support network, has proved very valuable to attend and present our work. A representative from Wits FHS has attended the annual REDCapCon since 2015. However, the many sub-Saharan Africa-based REDCap administrators do not have a budget to travel to North America for the annual international REDCapCon. It became apparent that an African REDCapCon would add value to the African consortium partners. Wits hosted the first REDCap Africa Day in Johannesburg in 2016 as an adjunct to the FHS research day, followed by three more REDCap Africa symposia in 2017, 2019 and 2020. Each symposium has been attended by one or more members of the VUMC REDCap team. The REDCap Africa event encourages attendance by regional and international REDCap administrators and end-users, as opposed to the REDCapCon, where only administrators attend. The REDCap Africa symposia agendas were a mixture of technical presentations and use cases, with plenary sessions presented by local academics as well as VUMC visitors. Delegates included local and regional faculty members, research institute employees and students.

Table 4. The number of delegates to the REDCap Africa symposia per year.

Year of event	2016	2017	2019	2020
Wits FHS affiliated delegates	69	40	27	42
Local (SA) Delegates	30	28	19	37
International Delegates	6	2	4	31
Total delegates	105	70	50	110

The novelty of the first REDCap Africa symposium drew large numbers of attendees (Table 4), including a number of casual attendees from the Wits FHS who were not REDCap users, but nonetheless wanted to learn more about REDCap, the Wits FHS' EDC strategy and its relationship with the VUMC. In subsequent years, the number of casual attendees decreased and comprised of REDCap administrators or highly engaged power users. The cost of intra-Africa travel is high and the number of attendees from the African region who were able to attend in person remained low. In 2020, due to COVID-19 restrictions, REDCap Africa day was hosted virtually using Zoom, and attendance was significantly higher with more international delegates than at any previous event. Another virtual instalment of REDCap Africa Day symposium is planned for 2021 due to the ongoing COVID-19 pandemic, but future REDCap Africa symposia will explore combined in-person and live streaming and/or travel bursaries to encourage regional participation.

REDCap Community Forum

The REDCap Community is an online platform where the administrative and IT support staff of a consortium partner institution can access software downloads, extensive technical documentation, a question/answer forum, consortium announcements, committee activities, events, and more [35]. The Community website provides a forum for interaction and dialog about REDCap-related topics with REDCap administrators around the globe, and is an essential resource for the development of an institution's capacity to host and support REDCap. The Wits FHS REDCap administrators have received technical advice or otherwise benefitted from discussions on the REDCap Community forum, while also enjoying the networking and sense of community gained by interacting with peers from other institutions.

Vanderbilt Relationship and Support

The development of clinical research informatics capacity and healthcare IT skills are particularly important in resource constrained settings like sub-Saharan Africa, and the Wits-VUMC partnership has contributed to the capacitation process at the Wits FHS. Initially the relationship between Wits and VUMC grew from an alumnus diaspora programme initiated in 2010 [36], and later expanded through bilateral visiting academic staff [26], custom REDCap development projects, joint grant applications and mentorship. New REDCap Consortium members in resource constrained environments may benefit from leveraging existing diaspora linkages, or from initiating new mentorship and capacity development collaborations with institutions that have mature research informatics divisions like VUMC.

3.4.2 Measurement of System Utilization and Growth

REDCap system utilization is reported in two main ways: the number of users and the number of projects. The number of users and projects on any REDCap system is available on the application's administration web page called the 'Control center'. The Wits FHS REDCap administrator has a monthly record of several usage metrics since system installation in August 2012. Other metrics were determined retrospectively by running MySQL queries on the REDCap database logs with the help of a REDCap external module named 'MySQL Simple Admin' [37]. These queries were used to identify and enumerate project or user account creation events. The descriptive system usage metrics we report on are the:

1. Total number of user accounts
2. Number of user accounts that were active each year
3. Annual increase/decline in number of active user accounts
4. Total number of practice and non-practice projects
5. Project purpose attribute of each non-practice project

User Accounts

A REDCap user account allows an individual user to access their own private repository of projects and data. The REDCap Control Center displays various metrics regarding accounts, for example the total number of user accounts, how many accounts were active in a given period of time and how many have become suspended due to inactivity. Activity is defined as logging in and performing an action

on REDCap. At Wits FHS, the period of inactivity that leads to suspension is 180 days, this may differ from institution to institution based on policy. We used a combination of ‘Control Center’ statistics and MySQL Simple Admin [37] queries to report the total number of user accounts on the Wits FHS REDCap system per year as well as the number of accounts that were active in a given year. The measurement is taken on the first day of September each year.

Additionally, the growth or decline in number of active user accounts were determined by taking the number of active users for a given year and subtracting the number of active users from the previous year.

Projects

A ‘project’ in REDCap refers to a set of connected electronic data collection screens and records that are related to a specific purpose.

When creating a project, end users are required to allocate one of five possible project purposes, namely: ‘practice’, ‘research’, ‘quality improvement’, ‘operational support’ or ‘other’. The Control Center report usually excludes practice projects from the ‘total projects’ metric, but we performed a query using MySQL Simple Admin [37] to retrieve the number of practice projects as well, and report these together with the total non-practice projects. We believe practice projects are an important metric of how comfortable users are to experiment and explore the system, something which is actively encouraged by our REDCap administrators during one-on-one or group training sessions.

Furthermore, we performed an annual breakdown of the non-practice projects by purpose, and report the percentage of projects in the categories of ‘research’, ‘quality improvement’, ‘operational support’ and ‘other’.

3.4.3 Measurement of System-related Research Outputs

One measure of the impact of REDCap on the Wits FHS is by reviewing research outputs such as journal articles and postgraduate theses. We performed a bibliometric survey to determine the number of research outputs from Wits FHS affiliated authors that relied on the use of Wits FHS REDCap for electronic data

capture or management, and report the number of outputs per year, as well as the subject domains across all the outputs for the period 2013-2020. REDCap has a built-in publication matching tool that will review PubMed databases for authors and affiliations that matches that of REDCap users or project principal investigators. We evaluated the list of 'potential matches' generated within REDCap, and only included articles and monographs in our results if they mention using Wits FHS REDCap as the data collection instrument in the methods or acknowledgements sections. In cases where no system is mentioned by name, we contacted the authors via email to request clarification, and only included the output if authors confirmed in writing that Wits FHS REDCap was used.

3.5 Results

3.5.1 User Accounts

There was a sustained – and at times exponential – increase in the number of user accounts from 139 total and 129 active accounts in 2013, to 7 128 total and 3 447 active accounts in 2021 respectively (Figure 1).

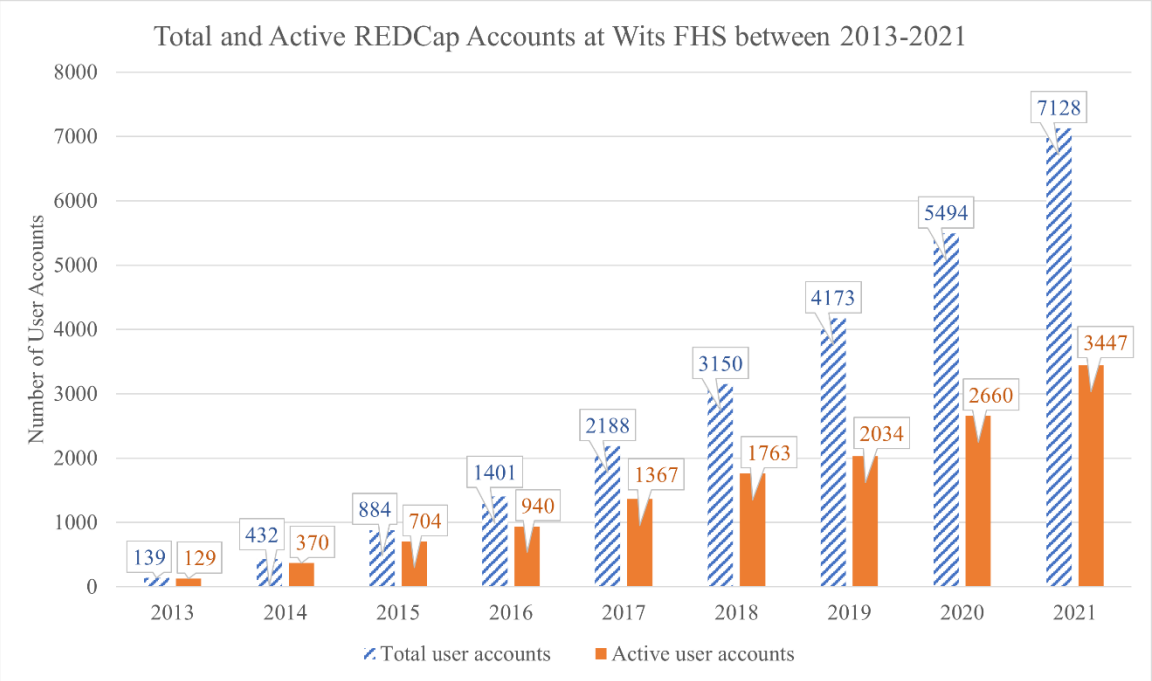

Figure 2. User account statistics for the Wits FHS REDCap system from September 2013 – September 2021. The total number of accounts as well as the active cohort is shown for each year.

The number of active users has increased 25-fold in 8 years; however the magnitude of the growth was variable (Figure 2). Except for the 2016, 2018-2019 periods, annual growth exceeded 25%.

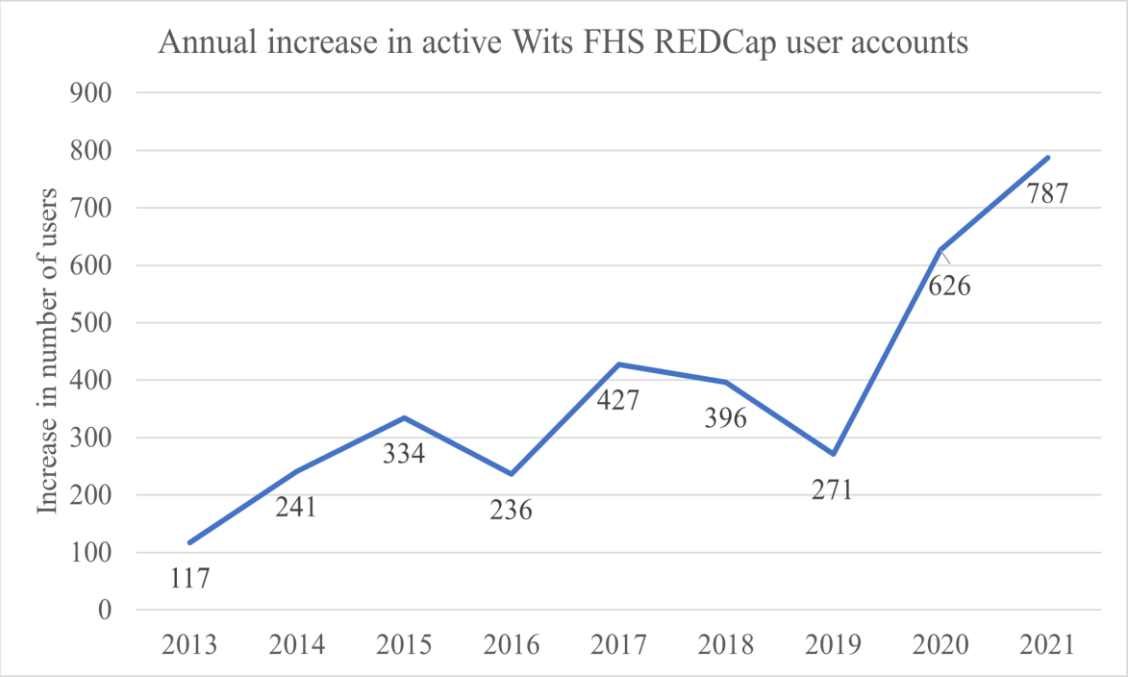

Figure 3. The increase in number of active REDCap users at the Wits FHS from 2013-2021. The values were obtained by taking the number of active users in a given year and subtracting the number of active users recorded for the previous year.

3.5.2 Projects

The total number of projects on the Wits REDCap platform increased significantly from 149 in September 2013 to 12 865 in September 2021 (Figure 3). The number of non-practice projects increased from 97 in September 2013 to 7 038 in September 2021, and accounted for 54.7% of the total number of projects in 2021.

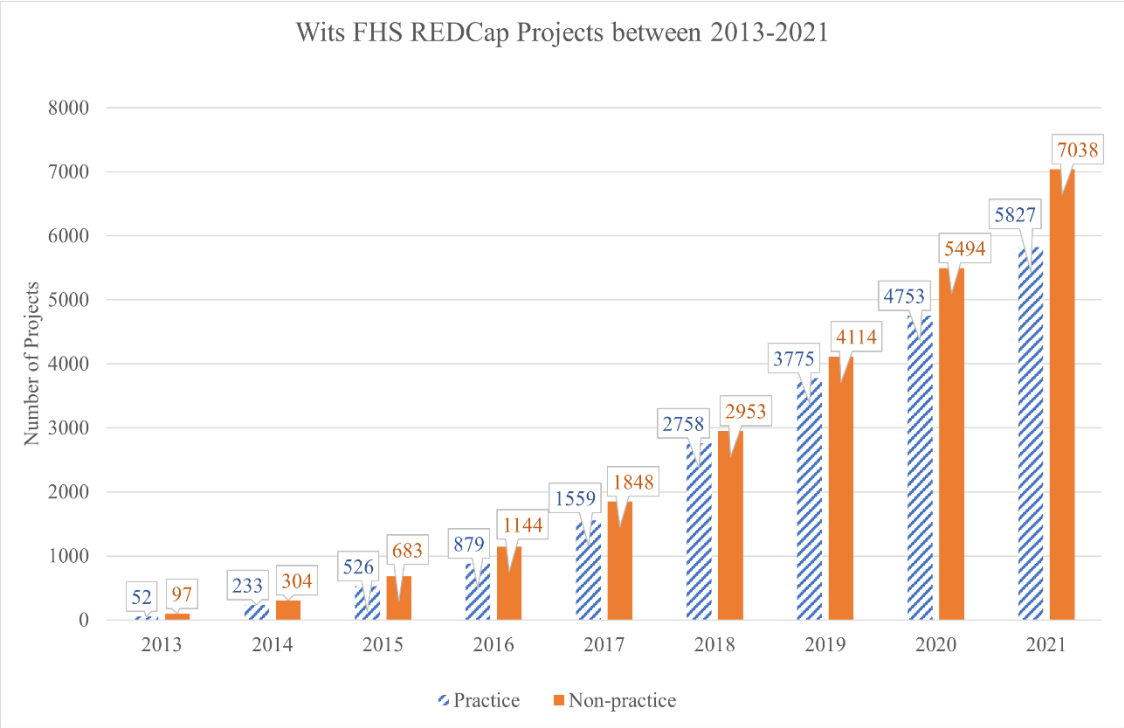

Figure 4. REDCap projects on the Wits FHS system per annum from September 2013 to September 2021.

Of the 7 038 non-practice projects on the Wits REDCap system in September 2021, the majority were for research purposes (3 952; 56.2%) (Table 5). The remaining 3 086 (43.8%) were dedicated to non-research purposes (Table 5).

The majority of Wits REDCap non-research projects in 2021 were allocated as 'operational support' [26.3% (1 850 of 7 038)], while 'quality improvement' and 'other' represented a minority [705 (10 %) and 531 (7.5%) respectively].

From Table 5 it can be seen that the ‘operational support’ category has grown to represent a larger share of the total projects every year (from 10% in 2013 to 26% in 2021), while research, quality improvement and other categories have all declined as a percentage of the total.

Table 5. The number of non-practice projects on the Wits FHS REDCap system from Sep 2013 - Sep 2021 categorized by purpose.

	Research	Operational Support	Quality Improvement	Other
2013	62 (63.9%)	10 (10.3%)	16 (16.5%)	9 (9.3%)
2014	209 (68.8%)	36 (11.8%)	38 (12.5%)	21 (6.9%)
2015	452 (66.2%)	79 (11.6%)	88 (12.9%)	64 (9.4%)
2016	757 (66.2%)	170 (14.9%)	116 (10.1%)	101 (8.8%)
2017	1223 (66.2%)	324 (17.5%)	169 (09.1%)	132 (7.1%)
2018	1842 (62.4%)	593 (20.1%)	265 (09.0%)	253 (8.6%)
2019	2523 (61.3%)	887 (21.6%)	392 (09.5%)	312 (7.6%)
2020	3145 (57.2%)	1376 (25.0%)	558 (10.2%)	415 (7.6%)
2021	3952 (56.2%)	1850 (26.3%)	705 (10.0%)	531 (7.5%)

3.5.3 Wits REDCap Publication Metrics

Two hundred and thirty-three journal articles and 87 postgraduate research monographs acknowledging the use of the Wits FHS REDCap system were published between 2013-2020. As shown in Figure 4, the number of articles increased over time as more users adopted the system, and as projects reached maturity and results were disseminated. The year 2020 saw a sharp decrease in postgraduate monographs that cite the Wits FHS REDCap system. This may be due

to a delay before a thesis or dissertation becomes available on the institutional repository.

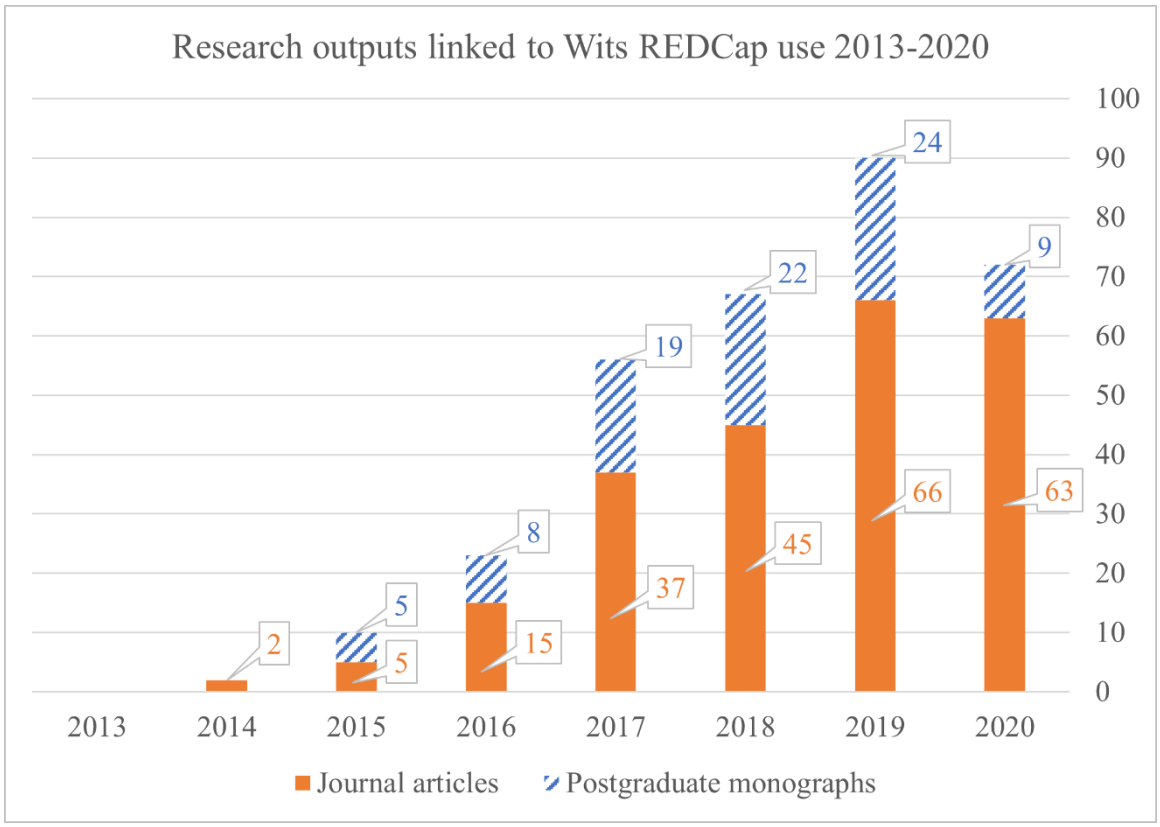

Figure 5. The number of research outputs linked to use of the Wits FHS REDCap system, grouped by publication year. Postgraduate monographs include PhD and Masters research works. Certain data included herein are derived from Clarivate Web of Science. © Copyright Clarivate 2021. All rights reserved.

A visualization of the research areas of the journal articles also illustrates the diversity of scientific disciplines impacted by REDCap at the Wits FHS (Figure 5).

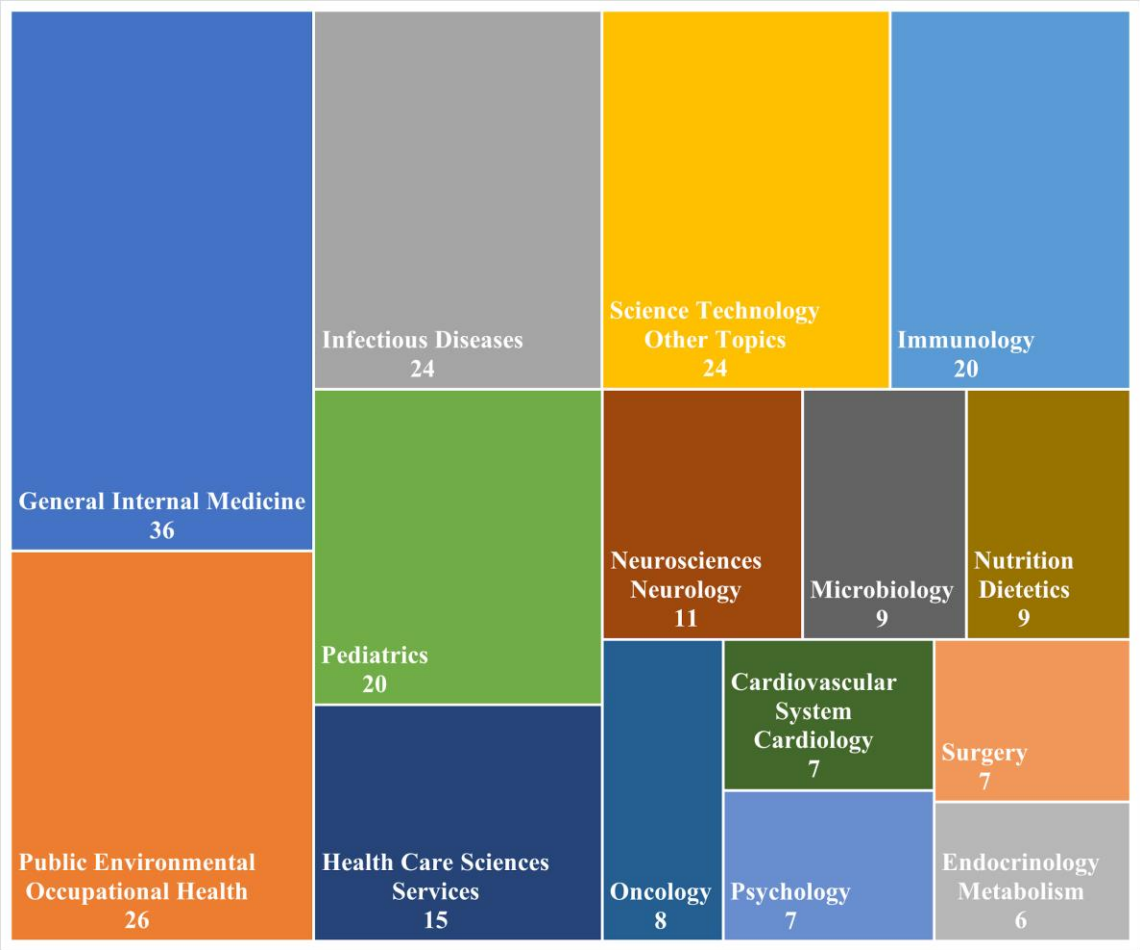

Figure 6. Treemap visualization showing the Wits FHS publications between 2013-2020 that were supported by REDCap, categorized by research area. This graph represents the top 15 out of 50 research areas by frequency of occurrence. Certain data included herein are derived from Clarivate Web of Science. © Copyright Clarivate 2021. All rights reserved.

3.6 Discussion

3.6.1 Principal Results

During 2012-2013, the Wits FHS implemented the REDCap EDC system to support both research and clinical service delivery data management needs [8]. REDCap provides researchers with the means for design and development of electronic data capture tools that conform with international best practice for the safety, security and

privacy of clinical data. REDCap is licensed by Vanderbilt University at no charge to government, academic and non-profit organizations, for use in non-commercial academic and research contexts [14,25]. By removing financial burden and providing tools and support channels that empower local research informatics leaders to serve the local research enterprise, the REDCap platform fills a critical gap in most research organizations [14,25].

During the period of 2013-2021, utilization of the REDCap EDC system increased steadily at the Wits FHS, as evidenced by the growth of users, projects, and publications.

The number of active Wits FHS REDCap users increased from 129 in 2013 to 3 447 in 2021, which is a 25-fold increase. Each year saw more active users than the preceding year, and with the exception of 2016, 2018 and 2019, the annual increase in the number of users was larger every year. While our records do not contain an explanation for the slower growth in 2016, the 2018-2019 period saw fewer hands-on workshops being offered due to the senior REDCap Administrator being on extended leave. In 2020 and 2021, the annual increase was 1.5 and 2 fold higher than any previous year, respectively. Two factors may have contributed to the 2020-2021 surge in active users: firstly, the COVID-19 pandemic drove the adoption of web-based instruments that could be accessed by teams working remotely, and secondly, the Protection of Personal Information Act (POPIA) was introduced in South Africa during 2020 and enforced after July 2021 [38]. As part of POPIA requirements, organizations that process personal information were required to use secure, auditable applications, and REDCap was one of only a few products offered by our institution that were compatible with POPIA requirements.

The total Wits FHS REDCap projects numbered 149 in 2013 and 12 865 in 2021. Of the 2021 total, 5 827 (45%) projects were created for ‘practice’ purposes and 7 038 (55%) projects were for non-practice purposes. The ratio of practice vs non-practice projects have remained remarkably stable around 45% over time. Practice projects are created during the formal hands-on training workshops offered by the Wits FHS, and the use of practice projects to test design ideas and prototype data collection instruments are encouraged by the Wits FHS REDCap Administrators during one-

on-one consultations. The REDCap application developers release updated features on an almost monthly basis, meaning that even experienced users might resort to creating practice projects from time to time to test out new functionality. A deeper analysis of user behaviour may be needed to determine conclusively the reason for the observed stability of practice vs non-practice projects.

Of the 7 038 non-practice projects on the Wits REDCap system in September 2021, the majority were for research purposes (3 952; 56.2%). The remaining 3 086 (43.8%) were dedicated to non-research purposes. This reflects the diversity of uses of REDCap in the Wits environment– as a clinical health record, a staff rostering and management tool and in a multitude of 'spreadsheet' type administrative processes in addition to research. Further innovative off-label uses of REDCap appear in the literature [39–42].

During 2013-2020, 233 papers and 87 postgraduate monographs that acknowledge the use of Wits FHS REDCap were published. The increase in research outputs occurred during a time when the Wits FHS research and postgraduate support office employed several strategies to increase research and publication rates [24], and REDCap was one of the contributing factors to the observed rise in publication metrics of Wits FHS staff and students.

3.6.2 EDC Support Strategies in a Resource-Constrained Environment

The growth in utilization of REDCap at Wits FHS was driven in large part by the trust generated by offering a reliable, secure service, and a strong end-user training and support model (Table 6). A critical success factor is that hosting and server infrastructure was supported by a highly experienced systems administrator, who ensured that appropriate security measures and disaster recovery plans were in place. Additional storage and computing capacity was added as needed. It was important to respond to performance problems when incremental upgrades were no longer sufficient. End-users were supported by a dedicated REDCap administrator available via an email helpdesk, one-on-one consultations, formal training workshops and annual symposia. The support team size was expanded over time to meet the increase in demand [REDCap administrator(s): 0.5 FTEs in 2013 to 2.2 FTEs in 2021, systems administrator(s): 0.05 FTEs in 2013 and 0.1 FTEs in 2021]. The

capacity of the support staff was improved through mentorship, professional development and participation in regional and international REDCap consortium activities.

Table 6. Summary of EDC adoption support strategies at Wits FHS.

Support strategy	Observations and Effects
Top-down organizational support	Official endorsement from management ensures that a system receives adequate resourcing for infrastructure and staff, and signals institutional commitment to potential end-users
Secure and reliable application, hosting infrastructure, and systems administration	Prioritizing reliability and security of the EDC builds trust amongst users. In resource-constrained settings, power, network and information infrastructure is often unreliable, and users fear losing their data
An enabling and accessible REDCap support team	A person or team who acts as “technology bridgers” [31] reduces anxiety and resistance associated with technology adoption
Regular hands-on training workshops	Structured practical training opportunities capacitates new users with a system, and serves as a mechanism to disseminate knowledge and good practices
Annual conferences or symposia for end-users	Regular academic events that promote the correct use of features and demonstrate the benefits of a system attracts new users while keeping existing users informed and engaged
Participation in REDCap Consortium activities	REDCap administrators’ knowledge and abilities are developed through interaction with peers from other institutions
Mentorship and capacity development relationships with established organizations	Institutions that do not have established clinical research informatics departments/capacity benefit greatly from mentorship and collaboration with experienced partner institutions

3.6.3 Limitations of this study

The principal investigator on this study is also the lead REDCap administrator for the Wits FHS. This makes them intimately familiar with the support processes and end-user interactions in the institution, but can lead to a lack of objectivity. For this reason, co-authors experienced with REDCap and clinical research informatics from outside of our institution were included to provide a more balanced and fair report.

3.6.4 Conclusions

The implementation of technology requires strategies to support and manage resistance from end-users. One of the main reasons for this resistance is inertia: end-users naturally resist change to familiar and deeply ingrained processes [1,5,7,15–17]. In our experience, and supported by findings from others [1,4,7,16,17], to overcome inertia, one needs to demonstrate the reliability of the system and benefits of adoption to prospective users, while at the same time easing the transition process by providing adequate end-user support. The capacity to implement and support REDCap in the Wits FHS was initiated through organizational and financial backing of the FHS management. This capacity was subsequently developed further through participation in REDCap Consortium activities like REDCapCon and the REDCap Community forum, and through a strong bi-directional relationship with Vanderbilt University Medical Center, the institution that created REDCap.

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The project was conceptualized by MK, IM, PH and RZ. The majority of the writing was done by IM and MK, with sections contributed by SH, BK, RZ and PH.

IM and MN collected, analyzed and prepared the data about REDCap system usage, training and symposium attendance, and bibliometric data.

BK, RZ, MN, SH and PH all contributed to editing and review of the manuscript.

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3.8 Conflicts of Interest

None Declared

3.9 Abbreviations

REDCap: Research Electronic Data Capture
EDC: Electronic data capture
Wits FHS: University of the Witwatersrand Faculty of Health Sciences
VUMC: Vanderbilt University Medical Center
FTE: Full-time equivalent
IT: Information technology
RAM: Random access memory
GB: Gigabytes
WHC: Wits Health Consortium
POPIA: Protection of Personal Information Act

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PART FOUR – CONCLUSIONS

4.1 Summary of Main Findings and Recommendations

The University of the Witwatersrand Faculty of Health Sciences is a large, heterogenous organization responsible for teaching, research, and jointly with the provincial governments, clinical service delivery in some of the largest public hospitals in sub-Saharan Africa.

While most of the University's finance, HR and core IT systems had already been digitized by the 2000s, research informatics and electronic health records remained challenging, mainly because of the complexity and diversity of healthcare and research processes, the sensitivity of health data, limited financial resources and the scarcity of health informatics skills and experience at Wits FHS and in South Africa in general. Additionally, the physical infrastructure in the Wits FHS affiliated hospitals falls under the mandate of the provincial government, and while some forms of clinical record-keeping is a joint duty, the Wits FHS is not responsible for the hospital information systems.

It was, however, clear to the Wits FHS leadership that an institutionally sanctioned and centrally supported research informatics infrastructure would become a mission critical component of its services in the years to come, and in 2012 the academic freeware system REDCap (Harris et al., 2009; Harris et al., 2019) was deployed at the Wits FHS (Klipin et al., 2014). The extent to which REDCap was adopted into teaching, research, and clinical service delivery by most FHS members, while operating on a relatively small budget, is viewed as a success. This dissertation is an analysis of the implementation and adoption challenges of REDCap at the Wits FHS, the strategies followed to overcome them and a reflection on the lessons learned, with the objective of improving our own research informatics services and informing other EDC and technology implementation strategies in resource constrained, research focused healthcare settings.

4.1.1 Drivers, barriers and enablers of EDC adoption at the Wits FHS

We performed an inductive thematic analysis of 14 key FHS informant interviews to identify what motivated our faculty members to adopt EDC technology, and which factors were perceived to be the major obstacles or facilitators to adoption.

Informants discussed their experiences with various EDC technologies, including REDCap. Adoption of new EDC applications was typically driven by institutional/managerial mandate, or perceived benefit to prospective users. In voluntary adoption scenarios, informants cited point-of-capture validation and quality control, increased findability and accessibility of records, improved data provenance, reduced data turnaround times, and the potential to aggregate many records with ease for operational reporting, academic research or advanced analytics as some of the main reasons why they adopted an EDC.

Barriers included variable availability of reliable power and networking infrastructure across all Wits FHS sites, fear of unfamiliar technology, fear of change, effort/benefit misalignment and lack of integration with other laboratory, imaging, or pharmacy information systems.

Enabling factors were a visible institutional commitment, promotion of a system, positive feedback from early adopters, easy to access support services, both formal and on-demand training resources, and finally, the configurability and value-added features of the system itself.

Many informants felt that widespread adoption and integration of an EDC like REDCap provides many of the benefits described above, however by creating dedicated and specialised information capture, management, and analyst positions the full value of health informatics can be unlocked.

4.1.2 REDCap implementation and adoption support strategies at Wits FHS

REDCap was deployed at the Wits FHS in 2012 (Klipin et al., 2014), and was widely adopted, growing from 129 active user accounts in 2013 to 3447 active user accounts in 2021, and being cited in a total of 233 journal articles and 87

postgraduate monographs produced at the Wits FHS between 2013-2020 (Maré et al., 2021).

Several valuable implementation lessons were learned from the initial deployment and the subsequent adoption support stages. We reflect on the effectiveness of our support strategies, and how they relate to the barriers and enablers identified previously. Table 4.1 contains a summarized version of our findings.

Value and fit

REDCap was appropriate for our diverse teaching, research, and clinical service environment because it is highly customizable and can be configured to meet a wide variety of needs. Configuration is done on an end-user level, which gives users a sense of control and empowerment. The interface is designed to be intuitive to non-technical users, reducing the resistance and anxiety caused by information technologies which may have a perceived steep learning curve. Configurability also encourages re-use of skills with the system, ensuring existing users return for new projects.

In addition to building their own data collection tools, users can access built-in reporting tools and data export capacity when more advanced analytics is required. A common complaint against commercial electronic data collection systems is the lack of transparency and access to the raw data, which can be an intentional customer retention strategy, but from our experiences ultimately frustrates and alienates users.

REDCap is also one of the most cost-effective solutions available to an academic healthcare organization, being free of licensing fees. Financial resources mobilised to implement REDCap are almost completely limited to an investment in an organization’s own infrastructure, skills and staff.

Credibility, trust and promotion

Support from FHS management, the University legal department and the Human Research Ethics Committee showed institutional commitment and leant the implementing committee credibility. In addition to investment in hosting infrastructure

and collaborating with IT specialists from the Wits School of Electrical Engineering, which ensured a reliable and secure service, the implementation committee included members from Wits FHS clinical and scientific staff, which provided familiar and relatable individuals to interact with new users.

Several key informants mentioned socio-organizational influences as important enabling factors to adoption. Some of the BMI committee's strategies to build in-house informatics capacity also increased the initiative's visibility and credibility, like its collaboration with Vanderbilt University Medical Center, and hosting of regional REDCap Africa activities. Several of the early adopters of REDCap at Wits included respected senior researchers, who went on to advocate the benefits of using the system to their colleagues. Some of our key informants cited these endorsements directly as part of the reasons they decided to try REDCap.

Another point in REDCap's favour was the fact that it was built with HIPAA compliance in mind. This made it readily compatible with the Protection of Personal Information Act (POPIA) introduced in 2020 in South Africa. Increasingly, both research funders and institutional oversight bodies, namely the Wits HREC require auditable compliance with POPIA, HIPAA and CFR 21 part 11. This is easier to do when using a system with built-in logging and data provenance tools.

User support strategies

Members of the BMI committee who initially deployed REDCap at Wits FHS remained in an application administrative capacity and went on to provide email and consultation support services to users. This service was not initially planned for, but grew organically in response to the needs of the users, and in retrospect, particularly in view of the results of our key informant interviews, it was one of the most effective adoption support strategies employed by the BMI committee.

Several different modalities of training materials are available to Wits FHS REDCap users. Tutorial videos and a Help & FAQ page are built into the system and available on demand. The Wits FHS REDCap team also developed hands-on training workshops on a basic and advanced level. Users who are more comfortable with independently exploring the system prefer the built-in help resources, only reaching

out to the support team occasionally to clarify complex technical points. However, there is a large cohort of users at Wits FHS that resemble the ‘late majority’ or ‘laggard’ categories from Rogers’ IDT model (Rogers, 2003), who appear to prefer the structured and facilitated learning environment offered by the hands-on REDCap workshops. The introductory level workshop in particular was an effective strategy to capacitate, familiarize and reduce user anxiety amongst those users who perceive themselves as less technically skilled.

Table 4.1 summarizes the findings from the two studies documented in Part Two and Part Three of this dissertation, along with our interpretation of how each strategy enabled adoption or helped overcome a barrier. In Part Three, we described seven strategies that we believe contributed to the successful implementation and adoption of REDCap at the Wits FHS, and by linking the strategies to the enablers/barriers identified in Part Two, we provide further support for the necessity or impact of each strategy.

The analysis of drivers, barriers and enablers was performed after the implementation and adoption stages of REDCap at Wits FHS. While our strategies were not crafted in response to formal knowledge of the drivers, barriers and enablers at Wits FHS, we nonetheless found them to be well aligned with the challenges present in our environment. We believe that this shows how a responsive technology support team can adapt over time to meet the needs of its users, by accepting constructive criticism and being willing to evolve rather than rigidly adhering to established industry practises that might not always be appropriate in every environment.

We therefore caution other implementers to not simply re-using our or other published strategies as is, but rather being sensitive to the unique needs and opportunities presented by their own context.

Table 4.1. Summary of Wits FHS REDCap support strategies and which barriers/enablers of EDC they relate to

Support strategy	Related barriers/enablers of EDC adoption	Observations and Effects
1. Top-down organizational support	Barrier: Lack of resources, infrastructure, and skills Enabler: Visibility, promotion and institutional commitment Enabler: Mandates and social pressure	Official endorsement from management ensures that a system receives adequate resourcing for infrastructure and staff, and signals institutional commitment to potential end-users. Even in the absence of explicit mandates, top-down support exerts implicit pressure to adopt
2. Secure and reliable application, hosting infrastructure, and systems administration	Barrier: Lack of resources, infrastructure, and skills Barrier: Fear of technology	Demonstrating reliability is critical in resource-constrained settings, where power, network and information infrastructure is often unreliable, and users fear losing their data /wasting their time and effort
3. An enabling and accessible REDCap support team	Barrier: Fear of change, technology Barrier: Ease of use and misalignment of effort/benefit Enabler: Promotion and support Enabler: Configurability and empowerment	A person or team who acts as “technology bridgers” (Ash et al., 2003) reduces anxiety and resistance associated with technology adoption. Supportive resources are available to reassure users that mastery is possible, help is available when needed, and adoption benefits are demonstrated that balance the effort and discomfort of changing
4. Regular hands-on training workshops	Barrier: Fear of change, technology Barrier: Ease of use and misalignment of effort/benefit Enabler: Promotion and support Enabler: Configurability and empowerment Enabler: Capacitation and skills development	Structured practical training opportunities capacitates new users with a system, and serves as a mechanism to disseminate knowledge and good practices. Formal training opportunities are also an indirect signal of top-down institutional commitment

Support strategy	Related barriers/enablers of EDC adoption	Observations and Effects
5. Annual conferences or symposia for end-users	Enabler: Promotion and support Enabler: Configurability and empowerment Enabler: Capacitation and skills development	Regular academic events are a platform for research leaders and early adopters to demonstrate the benefits of a system, and where the best practices and new features can be promoted. The events attract new users while keeping existing users informed and engaged
6. Participation in local and international REDCap Consortium activities	Barrier: Lack of resources, infrastructure, and skills Enabler: Capacitation and skills development	REDCap administrators are supported and developed through networking and interaction with peers from other international institutions
7. Mentorship and capacity development with established organizations	Barrier: Lack of resources, infrastructure, and skills Enabler: Capacitation and skills development	Institutions that do not have established clinical research informatics departments/capacity benefit greatly from mentorship and collaboration with experienced partner institutions

4.1.3 Suggested Improvements to the current Wits FHS REDCap support model

We believe improvements could be made in future by changing the delivery method of advanced training from formal, facilitated workshops to on-demand eLearning modules. The advanced sessions were meant to further capacitate users who were already motivated to learn and use REDCap, but the four-day duration and ad hoc frequency made it difficult for delegates to schedule time to attend the entire course. Moreover, many were only interested in a part of the agenda and not the entire comprehensive overview. The advanced techniques taught at those sessions are best retained when applied immediately, it was not always possible for delegates to align the training sessions with the start of a new research project. Targeted and on-demand training materials on advanced REDCap topics may be more effective than the original the four-day course.

Furthermore, the key informant interviews highlighted the importance of regular promotion campaigns to remind prospective users of the benefits of using a system, signalling institutional support and commitment to a single product. The annual REDCap Africa Symposium has provided some of this need in an educational and empowering setting, but on its own might not be frequent enough. We therefore propose investing more resources into the monthly REDCap Africa regional calls, where case studies, features and best practises are discussed online for one hour a month.

The final frontier of EDC at our institution is the implementation of enterprise-wide electronic health records. Several systemic challenges remain to be overcome before this would become a reality, including (but not limited to) finding an appropriate and cost-effective software application, reliable networking, power, and data capture infrastructure, integrating the government and university information systems and policies, and appointing dedicated data capture and data quality officers. Clinical staff should be enabled to capture clinical information while research data needs should be supported by the necessary processes for the capture of electronic data.

4.2 Conclusion

The successful implementation of REDCap at the Wits FHS was achieved by offering a dependable, secure platform with appropriate features for our environment, a strong support and training model to help users overcome fear of unfamiliar technology and demonstrate the benefits of adoption. Participation and mentorship from the REDCap creators and greater REDCap community provided support and peer review for the implementation and later growth of REDCap and other EDCs at Wits.

4.3 Limitations of the Study

I am a member of the Wits FHS REDCap implementing committee, and was the senior REDCap end-user support agent at Wits FHS between 2012-2021, and cannot be considered an objective party. While extensive consultation with domain

specialists both at Wits and VUMC was undertaken during the research to ensure there were no major oversights, this work should be considered an intimately detailed report from the coalface rather than an unbiased audit.

Secondly, I was inexperienced with the qualitative research methodologies used in Part Two of the project. However, the inductive thematic analysis methodology we chose was appropriate for a novice researcher, due to its flexibility and accessibility relative to deep approaches like discourse analysis or semantic analysis (Braun and Clarke, 2006).

Finally, we acknowledge that implementation research is best done as a prospective study with baseline assessments and pre-planned outcome measures, though retrospective studies like ours still add value by disseminating unexpected findings and identifying promising areas for future research. The study could also have been strengthened if we were able to compare our results to a similar EDC implementation at another institution, but we did not have ready access to a comparable case.

4.4 Opportunities for Further Study

During the project, we encountered opportunities for further research that may be pursued in light of our findings:

- A detailed analysis of the purpose, needs and lifecycle of each non-practice project on the Wits FHS REDCap system.
- A subgroup analysis of end-user adoption behaviour and how the use of REDCap features are affected by the availability of training and support resources.
- A review of the common data elements that could be used to perform secondary analyses using aggregate results across many different projects on the Wits FHS REDCap system.
- A survey of all Wits REDCap users and subgroup analysis of technology adoption behaviour categories using a theoretical framework like TAM (Davis, 1989) or UTAUT (Venkatesh *et al.*, 2003; Venkatesh, Thong and Xu, 2012, 2016).

- Development of a sustainability model for EDC infrastructure and support cost recovery

4.5 References Part Four

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APPENDIX A - SEMI-STRUCTURED INTERVIEW QUESTIONS

The questions that will be used to prompt and guide the interview include:

i. What are your main data management needs? (prompts: type of data /lifetime of storage/accessibility via internet or mobile)
ii. Do you use any electronic data capture systems to manage [needs mentioned in previous answer]?
iii. If REDCap is one of the systems mentioned in answer ii, then answer these questions, otherwise continue to iv:
    a. What did you use before REDCap?
    b. How did you hear about REDCap?
    c. If you switched to REDCap why and what were your experiences?
    d. If you tried REDCap and stopped, why?
iv. Why did you decide to use [systems mentioned in previous answer] to manage your data?
v. Do you allocate any resources (time/people/funding) to electronic data capture/management?
vi. Are there any electronic data capture or management needs that you have that are not currently being met by [systems mentioned in answer above]?
vii. Do you anticipate any new/future needs for electronic data management that will require new systems/resources?
viii. What are the drivers that motivate individuals to adopt electronic data capture systems?
ix. What are the enablers and what are the obstacles facing implementation or adoption of electronic data capture and management systems in Wits FHS?
x. What kind of support/skills/resources are needed to overcome the ongoing issues facing implementation of electronic data capture or management?

Respondents will be encouraged to use anecdotes to illustrate their answers to questions vi-x. The interviews will be semi-structured, so new topics might emerge and be explored as part of the discussion.

APPENDIX B – HREC CLEARANCE CERTIFICATES

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

R14/49 Mrs Irma Adele Maré et al

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M210551

NAME: (Principal Investigator)	Mrs Irma Adele Maré et al
DEPARTMENT:	Biomedical Informatics (Wits Health Consortium) School of Clinical Medicine
PROJECT TITLE:	Building Capacity as a REDCap Consortium Partner: Lessons Learned from Supporting REDCap in South Africa
DATE CONSIDERED:	28/05/2021
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Prof Scott Hazelhurst and Dr Michael Klipin
APPROVED BY:	Dr CB Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	24/06/2021

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary on the Third Floor, Faculty of Health Sciences, Phillip Tobias Building, 29 Princess of Wales Terrace, Parktown, 2193, University of the Witwatersrand. I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions.Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. **I agree to submit a yearly progress report.** The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. In this case, the study was initially reviewed in **May** and will therefore be due in the month of **May** each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

Principal Investigator Signature

01/07/2021
Date

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

R14/49 Mrs Irma Adele Maré et al

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M210552

NAME: (Principal Investigator)	Mrs Irma Adele Maré et al
DEPARTMENT:	School of Clinical Medicine
PROJECT TITLE:	Drivers and barriers to adoption of electronic data capture systems at Wits FHS
DATE CONSIDERED:	28/05/2021
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Prof Scott Hazelhurst and Dr Michael Klipin
APPROVED BY:	CB Penny Dr CB Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	02/07/2021

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary on the Third Floor, Faculty of Health Sciences, Phillip Tobias Building, 29 Princess of Wales Terrace, Parktown, 2193, University of the Witwatersrand. I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions.Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. **I agree to submit a yearly progress report**. The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. In this case, the study was initially reviewed in **June** and will therefore be due in the month of **June** each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

Principal Investigator Signature

02/07/2021
Date

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG	HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

2021/11/03

Ms IA Maré, et al
Faculty of Health Sciences
Division of Biomedical Informatics
Medical School
University

Sent by e-mail to: Irma.Mare@wits.ac.za

Dear Ms Mare

Re: **Protocol Ref No:** M210551
Protocol Title: *Building capacity as a REDCap consortium partner: lessons learned from supporting REDCap in South Africa*
Principal Investigator: Ms IA Maré, et al

Thank you for your e-mail of 2021/10/22.

I confirm that we have noted and approve of your proposal to extend your data collection window to include all records up to and including 2021/09/30.

Thank you for keeping us informed.

Yours Sincerely

.....
Mr I Burns
For the Human Research Ethics Committee (Medical)

.....
Dr CB Penny, Chairperson, Human Research Ethics Committee (Medical)

APPENDIX C – DEPUTY REGISTRAR PERMISSION

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

OFFICE OF THE DEPUTY REGISTRAR

13 July 2021

Irma Mare' et al
Staff/Student number (A0027982/ 691165)
MSc Medicine (Biomedical Informatics)
School of Clinical Medicine

TO WHOM IT MAY CONCERN

"Building capacity as a REDCap Consortium Partner: Lessons learned from supporting REDCap in South Africa"

This letter serves to confirm that the above project has received permission to be conducted on University premises, and/or involving staff and/or students of the University as research participants. In undertaking this research, you agree to abide by all University regulations for conducting research on campus and to respect participants' rights to withdraw from participation at any time.

If you are conducting research on certain student cohorts, year groups or courses within specific Schools and within the teaching term, permission must be sought from Heads of School or individual academics.

Ethical clearance has been obtained. Protocol number: (**M210551**)

Research expiration: (24/06/2026)

Nicoleen Potgieter
University Deputy Registrar

Private Bag 3, WITS, 2050, South Africa | **T** +27 11 717 1204/8 | **E** nicoleen.potgieter@wits.ac.za | www.wits.ac.za
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UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

OFFICE OF THE DEPUTY REGISTRAR

13 July 2021

Irma Mare' at al
Staff/Student number (A0027982/ 691165)
MSc Medicine (Biomedical Informatics)
School of Clinical Medicine

TO WHOM IT MAY CONCERN

"Drivers and barriers to adoption of electronic data capture systems at Wits FHS"

This letter serves to confirm that the above project has received permission to be conducted on University premises, and/or involving staff and/or students of the University as research participants. In undertaking this research, you agree to abide by all University regulations for conducting research on campus and to respect participants' rights to withdraw from participation at any time.

If you are conducting research on certain student cohorts, year groups or courses within specific Schools and within the teaching term, permission must be sought from Heads of School or individual academics.

Ethical clearance has been obtained. Protocol number: (**M210552**)

Research expiration: (02/07/2026)

Nicoleen Potgieter
University Deputy Registrar

APPENDIX D – POSTGRADUATE PROTOCOL ASSESSORS APPROVAL

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

FACULTY OF HEALTH SCIENCES

PROTOCOL ASSESSORS MEETING

Candidate Full Name: **Irma Mare** Supervisors: **Hazelhurst/Klipin**

Student Number: **691165** Date: **2nd June 2021**

School / Department / Division: **Department of Surgery**

Degree: **Master of Science (Medicine) specialising in Biomedical Informatics and Translational Medicine**

Title: **Support strategies for the adoption of electronic capture systems for biomedical research data and clinical service delivery records in heterogeneous, research intensive organizations in resource constrained environments.**

1. **Type study** *(tick all that apply)*:

- Quantitative
- Qualitative✓
- Mixed Methods
- Laboratory
- Clinical
- Other, please specify.....

2. **Is title of the study appropriate** (*preferably fewer than 20 words*)? Yes✓ No

Comments: The title of the study is appropriate

3. **Are the study objectives clear and linked to the research aim and title?** Yes✓ No

4. **Is the design of the study appropriate to meet the study objectives?** Yes✓ No

5. **Are the proposed methods and tools appropriate to meet the research objectives?** Yes✓ No

6. Is the study feasible within the resources of:

a) The applicant?	Yes✓	No
b) The department?	Yes✓	No
c) The time frame?	Yes✓	No

7. If this is a PhD protocol assessment:

a) Is the content original?	Yes	No
b) Does the content show the scope and depth of a PhD?	Yes	No

Comments: _____

_____

_____

_____

Do you recommend:

i. Additional revision/amendment of the protocol? Please be specific on the recommendations being made:

- Please indicate that REDCAP is HIPAA compliant
- Edit timelines for feasibility. For example, ethics might take longer than indicated
- Specify specific tests to be used depending on data.
- Comparing data to other available ones such as from Vanderbilt University could be valuable.

ii. The appointment of the proposed Supervisor? Yes✓ No

Nominee/s: The assessors approve the appointed supervisors

_____

_____

iii. The appointment of the proposed Co-Supervisor/s and/or additional co-supervisors? Yes No✓

Nominee/s: No co-supervisors required

_____

_____

Irma Mare

2

iv. Has the Chair of the Assessor Group signed the RECOMMENDATION FOR APPOINTMENT OF SUPERVISOR(S) OF RESEARCH REPORT, DISSERTATION OR THESIS form? Please attach.

Yes	No✓

v. Has the Chair informed the student and supervisor about the Wits ethics requirements, and that if required, they must have either a Wits Human Research Ethics clearance certificate or a Wits Animal Research Ethics clearance certificate?

Yes✓	No

vi. Based on the protocol provided (including any proposed changes by the protocol assessor group), does the student require:

1.	Human Research Ethics clearance certificate	Yes✓ / No
2.	Animal Research Ethics clearance certificate	Yes / No
3.	No human or animal ethics certificate is required	Yes / No
4.	Unclear, will seek appropriate guidance from the HREC/AREC committees	Yes / No

vii. Has the Postgraduate student and supervisor/s signed the ethics declaration form

Yes	No✓

Overall recommendation regarding the protocol:

i. Revision of the protocol to the satisfaction of the Supervisor (**NB: if HoD approval is also required, please specify**): (***Candidate**: one copy, list of corrections with page numbers and Supervisor approval letter – submit to PG Office).*

Yes✓	No

ii. Revision of the protocol to the satisfaction of the Assessor Group/Chair: (***Candidate**: one copy, list of corrections with page numbers, Supervisor approval letter – submit to PG Office and PG Office to forward to the Assessor Group Chair).*

Yes	No

iii. Revision of the protocol and resubmission of the revised protocol to the next Assessor Group Meeting: (***Candidate**: six copies, list of corrections with page numbers, Supervisor approval letter – submit one copy to PG Office / 5 to school assessor group administrator / for PhD, all six copies to be submitted to the PG Office).*

Yes	No

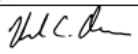
iv. Candidate goes ahead (*no revision required*):

Yes	No

Details of Assessors:

Name:	Email:	Sign:
Prof Maeyane Moeng	maeyane.moeng@wits.ac.za	

Irma Mare

Dr Jones Omoshoro-Jones	omsjon@dr.com	
Dr Clement Penny	Clement.Penny@wits.ac.za	
Prof Deirdre Kruger	Deirdre.kruger@wits.ac.za	
Prof Rod Alence	Rod.alence@wits.ac.za	

Details of Assessor Group Chair:

Name:	Email:	Sign:
Dr Ekene Nweke	Ekene.nweke@wits.ac.za	

Date: **2nd June 2021**

APPENDIX E – EXTENDED INTERVIEW TRANSCRIPT EXTRACTS ORGANISED BY THEME

E.1 Theme: Involuntary adoption: Mandates, pressure and punishment

Domain: Drivers	
Theme: “Involuntary adoption: Mandates, pressure and punishment ”	
Codes:	
Employer/regulatory body mandates	Some positions mandate the use of a specific data capture tool, or mandate the production of electronic aggregate data, but leave the choice of capture system up to the individual. Non-compliance may result in termination of employment or revocation of licensing
Research funder requirement	Research funders sometimes mandate a specific system, or specify a set of requirements but leave the choice of system to the researchers. Non-acceptance of the sponsor terms would result in loss of research funding
Influence by managers/ supervisors	Even when not explicitly mandated by job description, leaders and managers can set explicit requirements or implicit expectations for those they supervise. Students often use a data management tool preferred by their research supervisor
Informant2 22:58: “Absolutely. One thing that I realized when it comes to research people have an interest, meaning that there's actually a clinical question or thought they write it down in a sense that they created proposal they go through and fix. It's quite a long process, and people that generally enter or start that process or people that are we going to determine to actually finish what they've started. And obviously there would be. You know, the few minority that you just doing it because they have to and they’re expected to. But I mean, for for like for me I'll speak in terms of PHD's or consultants doing research. They generally. Want to actually conduct their research and they will do whatever it takes to have access to data that is clean that it's credible so they would be more inclined to use the software and they'll be more inclined to understand its value in there for one to learn more about it and initially come up with suggestions and ways of improving it because they also understand the value and the benefits of using it.”	

Informant3 04:44 : “As a lab, we made a decision to move to REDCap. Uh, so it came from me. …. Not that I know how to use REDCap. Uh, I told everybody else they have to learn how to use it. Uh, since I'm the consumer of the data, not the (storer) of the data or the (inputter) of the data. Uh, so it was a lab decision to start using REDCap and ….this came from me and another senior college in the lab”

Informant4 10:53 “Yeah, we actually our first experience with Red Cap was as a unit was we were doing a clinical trial that we sponsored. So we that means that we had to do all the data management. Uh, and we partnered with. Uh, some colleagues at University of Colorado. And they suggested REDCap, and so we actually. That database was hosted on their server at the University of Colorado.

Informant4 10:36 “And then for sponsored studies where …. we don't need to worry about budget in how we store our data. They'll usually have a database platform that …. they'll use that's - you know - that goes in line with their systems.”

Informant6 13:34: “Yeah, so I think it was really just pressure, you know. He had to record the information either way, which he did, but I kept on pushing him, you know, so that our systems can work on the same medium.”

Informant6 29:17 “Yeah, so it's really the user friendliness of, you know, I know we've been, for example, we've been forced to use online teaching now and we've jumped from Sakai to Ulwazi and all of these different factors. And I mean I can speak to it from that perspective. Is that if it's not user friendly, I'm going to be very resistant to using it for myself. Personally, I find again, I'm not sure if this is a age thing or personality thing, or find some colleagues are. Very motivated around trying to figure out a new system. I I'm not driven in that way at all I I just want something that you know I see it as a tool and I need to use this tool to get to a specific point. And you know whether it's research or teaching or whatever it is and the easier that tool is to use for me personally in terms of using user friendliness, I suppose that's my drive. Uh, around it and my limitation would be if it's too complex”

Informant7 12:21 I think I think you've said some of them. I mean mainly because they required to do it. Uh, or they do see benefits in doing that and that it can enhance whatever they're doing, but I think more and more people realize the importance of data, particularly there in a management situation.

Informant7 14:05 “And quite often you have to remind people. Almost shame them sometimes, by saying I still haven't received from you. And you don't want to do that, you want it to be an upwardly mobile type of approach. But you get so frustrated .... So usually I sent the graph out and I leave out the missing bit and I say I'm missing this. You know which is a fact, but it's not really the way I want to do things”

Informant8 18:29: “because that's your job requirement, it's just an expectation that you just do it. It's part of your job.”

Informant9 17:09 . “I mean, one of the things that I think might be of some value at some stage is that, uhm, we enforce as from the Health Professions Council some form of audit of practices. Yeah, people will do it begrudgingly, and and I know that you know an angry person putting data in will give you an angry outcome. But you know the fact is, is that at least, yeah, poor data is better than no data. I accept that good data is a lot better than poor data but that. So, so I think that those are the drivers.”

Informant10 18:58 A lot of the student groups, yes do use REDCap or their projects. I think. I think they're very often tend to be guided by their supervisors by what the supervisors are familiar with. And you know what they use or have used in the past.

Informant10 29:54 And I also think … we were forced into it a bit just because you know, those are the times we're living in, that you know, and the students coming up under us or so savvy and they know all of these things and we’re kind of pushed into adopting some of these methods as well, you know.

Informant12 08:38: “and in that study we are collaborating with University of Edinburgh. And because of all sorts of issues relating to… data protection, the University of Edinburgh insisted that we use that we encrypt data, and so we we've got all these requirements around encryption and and so on. So in the end we went with Kobo toolbox for for that particular project and it's encrypted on the University of Edinburgh server”

Informant12 31:08 “But now everybody does REDCap and you know, sort of within the our student body and they we actually teach them REDCap now as well as as part of their coursework. So they learn it in a couple of different ways, but if they’re doing (COURSE NAME) they actually do REDCap as one of the courses, or as one of the sections within a course I should (say). And they they have to develop a questionnaire on REDCap for an assessment so and so I think we're really trying to to promote, you know, sort of the use of electronic data capture as as a way to ensure better quality data collection

E.2 Theme: Downstream benefits/ efficacy gains: I can do more, faster and I can trust the results

Domain: Drivers	
Theme: Downstream benefits/ efficacy gains: I can do more, faster and I can trust the results	
Codes:	
Aggregation, reporting and analysis	Structured electronic data is easy and quick to search, aggregate or process for reporting or analysis
Re-use/ secondary analysis	Once data has been captured electronically, it can be used/re-used in many different scenarios
Data provenance	Electronic systems provide logging and enhanced audit capacity to ensure veracity and provenance of research data and medical records

Informant1 04:30 “Uh, certainly up until recently, but it's but, but not anymore. I used to examine all the log books of the country for the (SCHOOL NAME) and to get that data out and publish about. It it was a different type of data entry, so it was literally like 260 odd surgical procedures per training registrar. Uh, I think it was six exams of the college that (PERSON NAME) and I published and to be able to do that.”

Infromant1 08:06 (about Excel) “I think if you using it for your individual data entry that's fine, but if it's multiple users, I mean it's so easy, easy to delete something. Uh, so that that would be a limitation.

Informant1 17:24 “Look, I think initially without (UNIT NAME) database they there was definitely issues and again it wasn't at the time it wasn't my call to stop using it and again I think REDCap is great to to log data there on a tablet in the unit you know rather than Uh, have this floating Excel document that nobody knows whether whether latest version is. Why do you think it's great for that? But, for example, you would ask a patient Uh, are you a smoker? Yes or no? And then the answer would be no. But then there would be something under number of pack years. So I would I would I mean, and again I guess it's how you set up that that question there, but I would imagine if there's no all relevant questions to yes should not be available to a no answer.”

Informant1 22:38 So I think it's it's that having the information at the tip of your fingers rather than having you know paper files to find and sift through. I think the nice thing is is also you can you know you can search a electronic database to find specifics. Yeah, and I think again if if you. I think it would be easier to to. You know, get rid of the duplicate entries.

Informant1 23.26 So I mean, obviously also the fact that electronic data is the only way we can analyze data. It's the only way that we can import it into statistical software and and get, yeah, nice inferential statistics from it, so obviously that's is super important and.Yeah."

Informant1 26:53 Again, I think we'd need designated people. And those people should have access to. I'll give you an example like when I worked in the UK. If you like, I mean I was somebody who was analyzing patients blood for research purposes, but also for treatment purposes to determine treatments. So because of that role I had access to the electronic patients records and I could go in and I could enter my results. But at the same time that you know that that access that X is too. Maybe all to you know, not not edited entire record, because obviously that that has a lot of risk. But you know. So basically, when anybody else in any other departments uses that same patients, everything is available today. Because at the end of the day, if we are logging data for research purposes, so obviously I mean research is a major goal of this faculty. If we can, you know by means of a patient number or by means of patient identifiers, all log whatever we're doing. You know that it's accessible to everyone because the guy who's got you know pancreas cancer. Maybe the the new onset diabetes guy you know so that we can just all kind of start talking together."

Infromant1 29:25 You know the.The three out of of evidence based medicine where it's evidence based it's obviously patients entered an it's an. It's the experience and the decision making process of the Finnish and based on evidence based on unique patient data and personal personalized information on that picture."

Informant 2 06:05 I felt it was counterproductive because they're using the system is known as Venus. The system is also ideal for workflow in a sense that it's it can capture the time the patient arrives at the department, the amount of our radiation there they received, and then automatically it will try and create a template depending on which study the patient came for. And then unfortunately you still need to type the report. It sort of like gives you a window and it's a It word document and as soon as you done it, convinced that to a PDF. So even if one day you wanted to conduct research and look at maybe a specific group of patients, you will still need to recapture the data because you know you can't just export it as an Excel spreadsheet. So I think it's it's definitely not structured."

Informant2 11:57 In my view, it will be the creation of data capturing software. There is user friendly, meaning that you should have an option of walking around, for instance with the tablet and you just kept hearing the data while using a patient. Or just say things like a voice inside inside the integration where rather than the clinician sitting down and doing the typing they can just you know user voice over

function in related speech like that and also when clinicians understand the value of having the system such that. You know you make it clear to them that you know for research purposes you don't actually need to collect this data. Is there is available if you need to publish, you know you can just go into the database and then just retrieve the patients that you want. So you highlights all the things that they couldn't have possibly thought of, like the efficiency when conducting research and also in terms of. And you know tracking patient information you know rather than going to the records system in the hospital and trying to go through like thousands of files and information is not even legible because it was handwritten 10 years ago. So if they had to then see those benefits and you contrast what's currently happening now and the projected benefits. So you just put it out there for them to see. Then it'll be easier for them to understand why it's it's mandatory for us to be moving towards electronic health records."

Infromant2 22:58: "Absolutely. One thing that I realized when it comes to research people have. And interest, meaning that there's actually a clinical question or thought they write it down in a sense that they created proposal they go through and fix. It's quite a long process, and people that generally enter or start that process or people that are we going to determine to actually finish what they've started. And obviously there would be. You know, the few minority that you just doing it because they have to and they expect it to. But I mean, for for like for me I'll speak in terms of PHD's or consultants doing research. They generally. Want to actually conduct their research and they will do whatever it takes to have access to data that is clean that it's credible so they would be more inclined to use the software and they'll be more inclined to understand its value in there for one to learn more about it and initially come up with suggestions and ways of improving it because they also understand the value and the benefits of using it."

Informant2 24:53 "The I think for me the urgent needs would actually be to use the data for morbidity and mortality meeting such that every month or every two weeks or so you know exactly how many patients were admitted, how many died, what was the cause of death? Was there anything that you could have done to prevent this? So so use that the electronic health record system to implement or change policy or challeng it, or to actually improve patient care so I don't know if that answers your question because I feel for me that's like the number one priority is why we need it. Even if you stand in Parliament and you have to motivate people, you cannot solve problems that you're unaware of. You know, I understand the value of research, understand the value of, uh, you know, understanding you know who is admitted in the wards, but the whole aim of us being in the medical fraternity is to ensure that you you restrict or limit the number of people that die or end up getting getting complications. So if you don't know the situation, if you don't know what's happening, then you failed the patients.

Informant3 03:33 Uh, and they there's been a move towards using Redcap within the IT was in my lab is increasingly being used, so most of the post grades now collecting the data using Redcap databases. Uh, before that it was excel. Must the data goes this questionnaire based at (DEAPRTMENT NAME) lends itself quite nicely to Redcap questionnaires. So that's where most of the data is coming from, and then it's easy to download and the variety of formats wherever you want it in words in SS seizes CSV file and our file. That's all I really use an Excel. I suppose it to CSV file so you can use that date.

Informant3 21:25 :For my own. Experience there's push and pull factors. The the push is normally when your current. Situation, your current way of capturing and storing data is no longer meeting your needs. Uh, so you get pushed onto a new system, which is more capable. So for example, moving from Excel, it's not no longer serving your needs, so you move onto REDCap. The pull is. If you can sell it to the person that very early on so you get them to adopted before they become entrenched in the old, let's say using Excel, so selling them the the virtues, the benefits of using something like red cap. So there's the forced migration and there's the. He enticement mechanism I suppose for getting people to use it. And I know the faculty runs lots of redcap workshops. Uh, but workshops build familiarity with a tool with people that already want to use the tool. Uh, I'm not sure if it's a way of enticing people onto the tool using the tool, and I'm not quite sure how to do that.

Informant3 25:12 “One of the issues that the university is going to have to grapple with is. Uh, data, provenance and audit trails for data, specially since data fudging is becoming more and more common. … I don't know how much it's happening at Wits. If it is happening at all, I have no idea, but it is something that's a worldwide phenomenon. Uh, uhm and it seems to be data fraud seems to be increasing.”

Informant3 28:41: “Because that's one of the reasons why use. Analysis is code to clean all my data and things like version control, so it's all very and I make all those available publicly when I publish the data so that anybody can see how I clean the data, what the steps were in the process of how. If I did change anything, what I change in how I changed it, that sort of thing. So as long as there is an audit trail. So somebody can follow up and say Oh well, you made a bit of a stuff up here. Uh, so I was a bit dodgy in terms of why change this data point. And that's something you don't get from Excel, uh. You can just Willy nilly change things.”

Informant5 41:08 Yes yes. So I decided one my number of participants. It's too little to warrant even moving there two since I have to do the analysis myself anywhere and then the numbers being little themselves. Really, the move is not warranted and I can basically do everything in Excel. And. But there's only one one area where I feel. Yeah. I would be better served than just moving to to to at least

he I, but I I think it's not a train smash. I think I could still do it either in in Excel or some other. But I'll see when the time comes, I think just the display, the visual. Yes, if if if I don't achieve what I wish to do by myself in Excel. Then I feel like could. Migrate, but I've already worked up into Atlas TI I and and see if then the visual make up that the effects from from using it would be any better.

Informant6 11:00 “So what I noted is that a lot of what was going on in the school at that stage was a paper based information. Which is a problem obviously, around retaining a you know sensitive information, but also and I mean the guys were using Excel at that stage, but it wasn't that interactive to connect systems. If it kind of makes sense to you. So it was kind of working independently and. Yes, and and different individuals who are doing the administration had their own particular system, so I was really looking for a system that we could integrate, you know”

Informant6 27:33: “Personally I feel like it's a I'm on a treadmill and we constantly have to play catch up in relation to this. And I do think that individuals who do adopt this. Ah, it has an edge in relation to getting stuff done quicker. Uh, distributing to a greater audience. I mean is there's so many different factors, some of which I'm not even aware of at present. But I do feel like as the technology morphs and changes, we need to play catch up in relation to it. So for me personally, that would be one of the selective pressures in terms of, and it's not necessarily. You might not get it from, you know your head of school or anything in relation to that. Uh, but as times change, I think the individual in that specific task realises. If there is a more efficient way to do things you have to adopt that”

Informant7 12:21 : “Uh, or they do see benefits in doing that, and that it can enhance whatever they're doing, but I think more and more people realize the importance of data, particularly if they’re in a management situation. I mean, for instance, one of my key mottos with a lot of the things that I deal with I always say can I have the facts first before you give me the emotion and whatever else comes with it? And so the facts required them to attend to the data, so they will then go back and look at the data.”

Informant8 01:46: “Uh, and then in terms of more recently, I must say. They come teaching so teaching of GEMP threes and GEMP four students were clinical years. When they come, you know, a lot of our assessments are done online now, and so we are able to do the assessments online. Or rather, use an online platform when we doing bedside teaching and bedside assessments, and so there's a lot of rich data coming out of that.

Informant8 06:58 “The other part of it is the ease at which one can draw reports 'cause it allows you to go and have a look at a database very easily and also draw down an Excel or CSV file of the data. So that definitely makes it …very attractive.”

Infromant8 18:23 OK, so the the big motivator if you're not being forced to do it, because that's your job requirement, it's just an expectation that you you just do it. It's part of your job. The big motivation I guess for most people. All is well, it's different, but let's say for the registrars. If I take my register as they have to do it because it's part of their research collection like this. It's there in MMED and they know they've got to do it, because how else would they collect data for others? Like say myself as a consultant who just suddenly starts collecting data if it hasn't come from on top form, say the clinical manager saying we need patient data for this, but I just decided off my own and say, oh, I think it would be nice to collect. This information and that the motivation is really um. I guess it's it's feeling like you know that data is going to make a difference right?

Informant8 20:33: “Uhm, so when COVID started we went almost completely paperless with our recruitment process for registrars and medical officers. We said fill in the online form, the Z83 for the Department of Health for a job and upload all your documents, CVS etc. And all our interviews, everything was happening online virtually and all our scorings … are on excel spreadsheets and so on. Rather than people coming in, making notes and so on. … It wasn't the intention to do this for the sake of collecting data. It was the sake of making the whole process a lot more efficient. Electronic and you know, efficient. But having said that, you suddenly generate all this information and all this data that wasn't the primary purpose.”

Informant8 21:26 “So the motivation is different, and it's usually driven by a need to fill in… you are looking at technological solutions to something that you just think is archaic. Like you know, written stuff. But where people are like, I may have collected data for surveys, for instance, it’s out of interest, it's just a personal interest, saying I think it's going to … be of value to me in making …decisions for my problem.”

Informant8-19:40: “So I'm motivated because it's going to help me with my admin so I don't have…information scattered all over the place. It's in one place. I like having it in one database.”

Informant9 07:00 But the strategic situation was always very clear in my mind is that we needed. To to have electronic medical records, that we needed large data and that we needed the ability . You can manage it.

Informant9 08:43 Obviously I mean one of the things you always wanted out of the raw data environment was accuracy and … you and I know how much fudging goes into even entering information. Into a yeah, a data collecting system, whatever that system is. So, that was often for me quite helpful, but again, you know. From …a consumer perspective I really did like, I was keener on … the

outcome data and the statistics that go with it, than you know the actual you know table or the presentation. In fact, it was much easier to … look at, the nearly the narrative than the actual data. Quite happy to look at data from, you know, I mean, uh people put it together, but largely. To try and look at the accuracy of it more than … what it meant, because you know the meaning eventually is a two sentence meaning

Informant9 10:30 “See the the example we did of the oxygen is is that the data comes from from a secondary process you know? So people are not putting the data in because they are collecting data. They're doing it because they're ordering. And then you know, I mean that that clearly is where I think we, we yeah does. Is that commonly seen?”

Informant9 12:25 So so am I. I think that their drivers and there are. Uhm? Uh, so positive and negative drivers and. I mean the positive driver clearly is is when you can make systems easier. And and and again, coming to to the oxygen thing is, is because what when is done is is used a tool that can collect data. That then, you know, helps people you know achieve a. You know what is really in effect an Essential component of their lives. The the You know so so that becomes a positive driver. It just makes people's lives easier. And and what comes out of it then is is that you've got the ability to see more into it.

Informant9 13:34 “The next drivers I think are, you know, so, so ease ….and having achieved something for something else is I think really the big thing in the …clinical setting. I mean the one that really always makes sense, … is if you are able to get people to minimize what they do, say … you have an auto generated discharge summary. After people having to enter data because … they need to, for instance, be able to get a medicine … and there's (prescribing). You can do electronic prescribing or you can order blood results or you can order blood tests online and you get the results back immediately or you get it online again without any purpose, so that it kind of falls into the normal workflow. And and I mean today and none of us are have any difficulty going onto a computer. And putting in information that gives us access to something of that kind of nature, and that we then get the secondary data back. And if you get the electronic discharge summary done because you've had to put in a diagnosis to get a blood test and the blood test comes back, and then you know can confirm that in an environment becomes obviously something and. And yeah, if we could only get to a point where …a guy on a ward round on his smart device, whether that's phone, pad or whatever, and you … can record the instructions. Would be for me. Just a a wonderful way of then integrating this whole situation.”

Informant9 17:48 What makes me spend time putting data into a computer is interest, and you know whether that's my financial interests or whether I have this

wish to understand what's happening around Covid, yeah, or you know whether I follow the rainfall pattern in SUBURB in Johannesburg, you know. But I mean, …, there has to be something that you bring out.

Informant9 20:00 but the other which is an area that I've learned over the hard time is security. I mean. And that is yeah. Uhm, how well the program performs and half and you lose data. Uhm, no. I mean, yeah in early days we had to have always have a paper backup because you never were sure that you'd have your electronic background. So you know if you had a database that you were running every now and again you print it out because you know if it crashed, it crashed, and then, Umm. Even if you had the number of floppies or disks or other storage mechanisms, but but that I think is is, is is become. You know, the the the next one that I'm interested in. Uh, and then come. Eventually, what you can do with that data? I mean, yeah, it's and and and that data manipulation becomes is the reason why I, for instance, have never liked any of the database programs and I've always gone for Excel because you then I mean, once you had that you you always had to then import it again into another program to get something out of it. And I find that it's you know if you can do it all in one weekend. Hell of a lot easier and easier to manage. So, so those are the, the, the, the the positive drivers, the negatives.

Informant9 23:07 Well. Uhm, (INTERVIEWER), I think that there's there's one, well there's two statements that I think we've learned. And I mean, you know them as well as I do. The one is that you have to integrate it into making a person's life easier. Uhm, and the moment it becomes additional, it's just yeah,… a total disaster

Informant9 31:30 Go to WRHI and they. They are running a big trunk. And we want the secondary data after that big trial. Give them a tool. This is how you yeah this. When you see the patient. This is the date. This is where you go and that becomes straightforward. And when they need to have, yeah, repeat data, that's quite easy. And if they need an analysis of the outcomes that that is available. Within reason, to them with with with gradients. But the secondary data that I think will need expertise.Yeah, and and then can be much more. You know much more. You know? Positively interfaced with.

Informant9 32:57 Yeah, so I think that we need to start thinking about how we going to apply big data. Into the health system and and I think we're going to get into. More and more complex diagnostics and and and treatment algorithms. They're not coming so so. How how would I want to? Put us into a suggestion that we in a position to do that natural for one is that we at least got some of the background data. But more importantly the skills. So and and and that for me is really the. The yeah. The long term issue. And I do think that I mean if one is going to start talking about it is is that I don't think we are. Making people sufficiently

competent at these skills to to achieve. No, why would I be talking to you about that in this setting? Because I do think that we don't over it or we do not sufficiently emphasize the need for information. I don't think it is. And I'm I would hope that we would get people. To start thinking that that's the norm.

Informant10 16:28 Yes, definitely, uh, particularly in their clinical rotations for for. I'd say almost all of them. They've got some form of logbook and for that rotation where they'll need to, you know they need to They need to show evidence of attendance at tutorials and calls, and they need to show evidence of performing procedures and various things, clerking patients and and presenting patients. So yes, there is. They definitely do that. And and in terms of that, now is currently all paper based. And we have been trying. A long time to digitize this. And to get an electronic portfolio going for them so that yeah, so that it's quick. It's easier, it's more efficient. There's a, uh, a central way to access that data and to monitor their progress. And you know. But it has been a real real challenge.

Informant10 28:06 “for me, I would say that I think the benefits of having that electronic data capture is that you've you can have a lot of information in one place, … so there's centralization of your information. It's much more easily accessible. It's much easier to track. You're not going to lose your bits of paper, and you know. Have your records go missing. It's space because you know, certainly. I mean if I think about that, like patient records, you know, having cabinets and cabinets full of patient files versus having all of that information in a (file) on a USB or something you know it. I mean, it's just incomparable, so it's so storage space, the ease of access, the centralization of the data. Those are all things that I think are benefits that would drive it.

Informant11 35:15” Then the third is I feel like we’re only tapping into maybe 1 to 2% of the potential of our data, because once you have this data the way you data mine and you use big data because very soon if we all adopt this, this this electronic approach, very soon we'll have a lot of big data. It won't be in filing cabinets, it will now be big data and I think how, how you ask questions of that data and how you interrogate it. I I think actually having formal courses and formal programs. Not everyone is interested in it, so I'm not saying we should do it for everyone. But I like, I know there's a discussion about a data science institute or something like that, but I think developing more data driven initiatives, the university can think about how to resource those.”

Informant12 32:15 “I suspect that he realized that that there was a bit of effort up front, but that actually having to capture, you know, sort of like 'cause. Sometimes our student groups can be 65 students having to capture 65 paper questionnaires, versus, you know, sort of like you have to do one up front and then after that you have your data and you can. You can see it in lots of different ways and I think I

think. That was, that was the and I think actually once he realized it wasn't as hard as he feared, because I do think there's also this thing about something new and and having to learn a new thing. And so there's resistance around that. But once the barrier was broken around around, actually I can do this. It's it's. It's not difficult, it just requires a little bit of of thinking and and you know, I mean with those we don't even have skip patterns because basically, you know, sort of everybody gets asked every question. So it's not even completely. I mean, I think the things that are a little bit trickier when it comes to programming. A questionnaire that that involves sort of logic and skips and wanting to you know, is that it it. It takes, it's the the thinking process of that is sometimes a bit, you know, sort of like requires a little bit of insight, but. Around something that's straightforward, it's it's actually, you know, mastery is actually really achievable, and, UM, yeah, so and I think I think there's something really nice in being able to. Especially when you're busy like he is to be able to take off from, you know, sort of tasks and and it's really nice that that's now no longer a big thing that hangs over his shoulder.

Informant12- 39:18: “And I think at the end of the day, if I know that I can get data in a format that I can use for data analysis. And that for me is the critical piece that I have. Consistent, reliable. Data that is at the end of the day, usable in the format in which I need to use it, and you know that that actually is very helpful.”

Informant13 12:17 “ So we have like local installations of my SQL and and and and and the Postgres and when we, uh, once once we study has passed away or out the operation in stage, we're done with the data collection we need. We keep over data into our Microsoft SQL Server database, which we're using as our data warehouse.”

Informant13 22:52 “Yes, so like for example, the system will have in the clinics are is an offline system, which means I've every clinic has its own database. And I've been wanting to try to move that to a central database and online web based database where all the clinics we just do a query from the same database 'cause at the moment we have to go every week backup. We always at eight or nine databases and we integrate them into into one database.”

Informant13 25:31 “For me, if a long term goal would be to a movie at the clinic system are into into an online system that we are, we should be able to say OK, this patient that we saw in clinic is the same patiently we're seeing in clinic because. I'll share some of it. Patients are, we switch we clinics. It's either, uh, maybe we have moved to a new village because we have gotten married in a new village and they are what happens in the clinics will be declared the lost to follow up. But with people are continuing care somewhere and they also sometimes are people. We are using our multiple clinics. I don't know why. Maybe, uh.”

Informant13 26:23 “You see, the same patient is going to two different clinics. So if we have a system that is integrated because we only pick up these things at the end once when we integrated our other databases. But if we have one system then we do know and also with the hospital system when you we just help if we can just have one system that just us from the clinic or the weight of a hospital. When you would be able to create a follow our somebody say trajectory from a from where clinic visits up to the time they get admitted and the discharge from the hospital and we outcomes.”

Informant14 11:58 “And particularly when patients, lives are affected. When we make strong recommendations on how what food they must buy and how they must live their lives. I just think there's a burden on medicine to actually have better data in the background before we start banging our fists on the table.”

Informant14 17:34: “Uhm, what you've gotta try and do is design this system that works for the doctors and the nurses. If it works for them. The ones who are actually seeing the patients, not the ones running the department, who are running the hospital. If it works for them and then it'll work, but it has to work for them and the only way it works for them is if it integrates the lab results. If it integrates radiology and if it integrates their clinical summaries.”

Informant14 23:50 “And honestly, like I have had to audit some of the findings that the HIV world and the quality of that data entry is often very, very poor. Not all of it, but some of it is very good. But often it's very poor. Uhm, (often), you know we have had to deal with situations where data’s (entered) and you go in and you do an audit and you find data entered three days ahead. You know, uhm, and every doctor or nurse will tell you the story of going to certify a dead patient and finding blood pressure results entered in until tomorrow morning. Yeah, so like those are kind of things that are like a dime a dozen. It's just. Yeah, it's just the way the world is.”

Informant14 36:44“ Just trying something small, like the NHLS, is trying to work out those politics. Trying to find a way of harmonizing that without all the drama and the politics, would be just so useful. And trying to like look at radiology, trying to work out how to harmonize and digitize all of that stuff and link it to the pharmacy. Look at prescribing practices and things, you know, that could be gold.”

Informant14 46:00 “One of the things about COVID I've noticed is this cottage industry of these people searching their basements and find fraud in in in clinical research. And it's become like this huge industry. And it's quite scary as a clinical research of it, because like. Yeah, these guys just like pull out these Excel spreadsheets and they say I can see fraud. I can see you cut and paste the cell

and I can see that you did this and Iran is just feeling that Alice on this massive datasets using my XYZ skills and there's no way this exists. You know the chance of you having seen this is 000001 and I think that there's something to be said for starting to reposition in analytics space rather than in the design space."

Informant14 50:00 Yeah, so he's on his program and I had remembered that I'm thinking God will waste of time and she was quite like dismiss it at the time and it's one of the most powerful things that he actually is. That and like in the last 20 years, he's published again and again and again and some of the most amazing data I have ever seen. You know, I was completely wrong. So yeah, I'm dismissive here and then. Sometimes these datasets, even the small ones which clicked relatively. Yeah, they're large distances, but they clicked.To be small amounts of data collecting well, continue huge amounts, and I think that that's something to think about is like where is it easy to collect large amounts of data that comes through the door creatively, easily, and relatively reliably? And what can you tell from that you know?

E.3 Theme: Obviating transcription: It all happens in real time

Domain: Drivers	
Theme: Obviating transcription: It all happens in real time	
Codes:	
Turnaround time reduction	By using primary electronic data capture, the turnaround time associated with paper document transcription is eliminated. Data is available for quality control, analysis or reporting immediately after capture.
Capturing twice / capturing on paper	Mistakes are inevitably made both when data is entered into a paper CRF and when paper documents are transcribed into an electronic system. By removing the paper capture step, one of these two opportunities to introduce errors is removed. Paper records are also often handwritten, with varying levels of legibility
Error reduction	Electronic data capture systems can be configured to ensure data formatting standards and logical data quality rules. Since these are in place at point of capture, a mistake can be corrected while the patient/research participant is still present, while errors with paper records are usually discovered long after the subject's encounter has ended.

Informant1 22:10 "I think it's obviously just the, the ease of use, and having it readily available and if I just think of, you know, some hospitals in private would have (an) electronic app where the doctor immediately gets the patients' results on his phone. So the data is immediately available to him to make a decision, at the bedside.

Informant1 22:38 So I think it's it's that having the information at the tip of your fingers rather than having you know paper files to find and sift through. I think the nice thing is is also you can you know you can search a electronic database to find specifics. Yeah, and I think again if if you. I think it would be easier to to. You know, get rid of the duplicate entries.

Informant3 11:53: "I'm allow you to input the data immediately, so you missed out a another step which could cause error which is transcription errors from paper into electronic. So the patient or the subject could into the. Uh, if you got a iPad or something like that, you get into do it online or even just a computer in the lab. Uh, so that's one of the big thing was you just left out there error, which comes from describe transcribing data. An if you compare the ability to set up a Redcap interactive questionnaire relative to something like the old Ms Axis, so much. Yeah.."

Informant3 17:37: "The gain is absolutely that you leave out the transcription. Component of data capture? UM, it's direct input. And in terms of yeah, I don't see

it is taking longer. Uh, you mentioned taking the capture, taking longer, see it taking shorter because you messed up that data. Capture said the only thing that takes longer is a little bit of a pain. Setting up the questionnaire or the format you want to develop. But that's not a hardship. A little bit of time spent at the beginning pays dividends later on."

Informant5 10:54 What I did was I. Unfortunately, I still did my my. My question is where hard copies handed to students and then collected. Then I had to go input the data. A painstaking experience. But once I had it in Excel. Uhm? I wished at a later time, but I had also used the Microsoft Uh. Questionnaire. Form but I I didn't in any case, so I I did it manually, but transferring to to excel and for analysis of used and I'm still not very familiar with all the aspects of SPSS, but all the basic stuff.

"Informant9 10:00 I mean I think so, yeah, there's no argument that when nowadays has to be in a. You know if one is going to. Have appropriate reporting, particularly in processes, is 1 needs timely information and timely information can only be obtained if it is done prospectively. Come in, uh and and I mean just the, for example"

Informant10 28:00 "And if I think about UM. What we're what we've been trying to do with the with the digitising, the log books and the workplace based assessments and all of that and that that the benefits that we have been trying to. Yeah, a explore. Explore, explain, kind of explain to people is um. That again, it allows. It allows for more kind of continuous tracking of students. And in terms of real time tracking, instead of having things come up much later where you look back retrospectively and then it's too late to do anything about it. And so so real time tracking, having more or at least more efficient and more up-to-date review of your data. I think it is a benefit."

Informant11 07:02 "I had a couple of students who are engaging with you. This was some years ago. (PERSON NAME) and others to try to sort out REDCap databases for our studies. And you opened profiles, but then we couldn't access them, and what happens is, the study doesn't stop, so the study keeps going on, right and what happens is you create a very big data vacuum because someone can't enter data, or data is collected, it's not checked, it's not entered, it's not QC'd, it's not anything in and you just need that to go on for a few months and suddenly you have stacks of paper that high, and then you introduce a huge amount of human error. And so we had all of this, you know, then they started entering the data into the database, and when we had it checked, it was like 17% of the data were wrong, 12% of the data were missing. Now those patients have come and gone so we can't go back. So so having access, you know, just coming back to that, it's really very central to how useful these things are so."

Informant11 09:57 “So what I like about? Uh, databases like REDCap is that I think, uhm, they’re easier to to keep your finger on the pulse of the study so you can do interim data analysis quite easily, as opposed to with Excel, you’re copying and pasting bits out of them into something like R or you extract to it so, that’s basically my likes and dislikes.”

Informant11 14:09 “You know, I like I would prefer a system, that uhm, and I know it's asking a lot, but like rather than me going to it, it comes to me when something is wrong.”

Informant11 23:01 “I feel like so so so often when you have data queries right? Uh, uh, you you send them to the site and the site says, well we have to go to the archive. We have to pull out the files. We have to look at and sometimes like you know they keep files for a couple of years and then they’re limited in space and they call metro file and then they take the files to Klerksdorp or I don't know Springbok or somewhere in the middle of nowhere right? And then when you ask them for the data they say so I, I'm giving you real numbers. A few weeks ago we needed it data from a study that finished in 2017 and we were told to wait seven weeks. Seven weeks is over two months. Because the files have been archived and so they have to make a request to metro file, they have to fetch it. Then they have to curate it. And there's a whole lot of chain of custody documents that need to get signed before anything is moved. And this is how it should be, right? It's patient data, so I feel like if this was an electronic thing, I press a few buttons and I'd have it and I don't have to wait seven weeks.”

Informant11 23:58 The second thing is the and I have these files here. The storage of CRFs and data in a paper form. It's just it's so burdensome. So there's a big footprint. You could have all of these files, but it's also like you know you everything has to be under secure lock and key. If you need space in the room and you gotta move files, you gotta sign 10 documents before a file can move from here to there, so it becomes incredibly difficult. The third is so, for example, we had a break in a few years ago and I don't know what they thought we kept in our filing cabinets but they were rummaging through filing cabinets, now, you know these were these were files that we said we're locked and closed. All the information is there. There shouldn't be anything missing, but now we don't know anymore. And because it's a closed study, I can't take someone who's busy and say, you know now go check these files for completeness. So I really think that that paper is absolutely obsolete and that there's just no case to be made for doing it this way anymore, right? So now four electronic. You know, for all the same reasons, I think electronic has a low carbon footprint. It's more easier, it's more real time. And see whether the the other thing is. We can also see whether the nurse or the recruiters doing the job properly.

Informant11 25:13 “So one thing that we often find and you'll be surprised how common this is, is like scribbling and scratching and like a foul, scratched type writing on these CRF's and then you have to send queries right? And you say I don't understand this. What is this? And I would say that happens about 20% of times, with 20% of documents there is something we can’t understand. So if this was electronic then of course it's typed and so that takes away a whole lot at 20% worth of grief.”

Informant11 25:42 “So, so I think that's a good thing for electronic and and and also you know it's it does allow. It does allow for a reduction in data entry mistakes. So so if you still now have to copy from the CRF into the database, you're going to make mistakes. But if if there's no now we have electronically importing the CRF into the database, that that's perfect. There's no mistakes there”

Informant12-16:17 “Like I, I personally think that it's way more useful having the data already in electronic form and being able to see it immediately. So we were able to be much more responsive while we were busy learning how to deliver, you know, sort of online content because as students. Actually, I must say, especially in the beginning I think it was all over our, you know, levels of stress and anxiety in the beginning, but students wrote a lot of feedback and it was fantastic to be able to access it quickly and and to be able to come. You know, really, really be, you know, sort of like use the data to plan the next course. So so that was was one example of of where we've done that.”

Informant12 20:30 “It means the interviewers can't progress until they've scanned that consent form. So it just builds in. In in those sort of checks along the way, which I think was so valuable because there's no risk, then dead and interviewers sort of like doesn't, doesn't complete the informed consent process and you have a recording of of exactly when that happened, when the the you know all of all of those sorts of things which are valuable.”

Informant12 21:26 “the only thing that I would say is that I would never collect data that is not electronic, you know, sort of in terms of a research project going forward. Whether it's interview administered or whether it's self-administered, absolutely, I would not even consider it. It's transformative. I think the level of errors and all of that sort of thing is just so vastly reduced”

Informant12 24:22 “So I developed the first student evaluation on Redcap because I already had familiarity with REDCap, already experienced the benefits, and then I tried to persuade our program administrator to to set up the future. REDCap and evaluations. And yeah, he was very resistant to start off with and didn't want to do it. And then you know, I said I, you know, 10 training. Here's the introductory

session. Let me show you at the basics so that you can get started. You can use basically my questioning had already developed and just modify it. You don't even need to design it from scratch, and UM. And it took quite a while before he actually was able to do it. So, so it was definitely a case of of, you know, sort of like really reluctantly doing it now. He enthusiastically does it, I will say. And and, and he's quick to to do it. And then he sends us the data set, you know, sort of. At the end, you know when when it. Once he's he's satisfied that two things you know we're not going to get any more responses then he packages it up in the emails it to the coordinator and we get it literally, you know, sort of within a few weeks of the modules. So which wears before? I mean there were some times times we like, you know. Six months later we still didn't have the captured spreadsheet. Of the evaluation so.

Informant12 31:08 “But now everybody does REDCap and you know, sort of within the our student body and they we actually teach them REDCap now as well as as part of their coursework. So they learn it in a couple of different ways, but if they’re doing (COURSE NAME) they actually do REDCap as one of the courses, or as one of the sections within a course I should (say). And they they have to develop a questionnaire on Redcap for an assessment so and so I think we're really trying to to promote, you know, sort of the use of electronic data capture as as a way to ensure better quality data collection. And and the fact that it can be, you know, interview administered or it can be self administered I think makes it really usable across any study, regardless of whether it's community based or whether it's like with health care providers or you know whoever it's with.”

Informant12- 29:05 “That's a massive benefit is is being able to see immediately if there are any either questions which aren't working well but also. Just to do quality checks because like for example in the (PROJECT NAME) we we have to enroll and register their mums onto onto well through through an organization onto the actual system. If they're in the intervention group so and So what that means is we have to capture their cell phone number and there's like standard data that we have to collect which we submit for registration, which we also do in our secure way. And but anyway, I mean that so we had to. In the beginning we were checking a lot of that because we couldn't afford to have errors, because if there were errors then that meant that, uh, mom couldn't be a registered on to receive the intervention. So as a result we we found that incredibly useful. Being able to do the live data checks and being able to know where you are in terms of the number of questionnaires completed on a given day. You …could feed back on quality and retrain along the way, which oftentimes … in the old paper based way you know you only discovered those things (late) and then you lost data. So so this way we can course correct and and not lose data you know. So so for me. That's a no brainer…”.

Informant12 32:15 “I suspect that he realized that that there was a bit of effort up front, but that actually having to capture, you know, sort of like 'cause. Sometimes our student groups can be 65 students having to capture 65 paper questionnaires, versus, you know, sort of like you have to do one up front and then after that you have your data and you can. You can see it in lots of different ways and I think I think. That was, that was the and I think actually once he realized it wasn't as hard as he feared, … UM, yeah, so and I think I think there's something really nice in being able to. Especially when you're busy like he is to be able to take off from, you know, sort of tasks and and it's really nice that that's now no longer a big thing that hangs over his shoulder.

Informant13 28:46 “I mean for us the main reason why we had to move, uhm, it was taking a lot of time. Uh, you collect the data, then you need to have people that you are entering the data into the database, then you also you need to have people that are checking the data. So, when we were on paper, it used to take us at least. At least four months from the time that we finish one census round, to the time that actually we have data set that is ready for analysis. And to cut this, this was one of the motivating factors to say, no, we're taking too much time to get the data ready. If we move to an electronic system, the data will be available immediately. If we collected the data today, tomorrow we should be able to produce a report, ah, a data quality report on the data that we collected today to say, these are the mistakes that were done in the field, can you go and correct them? Where, in the past, sometimes we pick up some of these errors after the contracts with the fieldworkers have already been, uh, have already ended, and when we don't have the fieldworkers to go back to these individuals and … correct the mistakes. So apart from getting the data processed …on time and the also with other fields was that you ah, I think, clear wells improvement in the quality of the data. Because when we are we could do. We can pick up issues and fix them in real time. I think these are the two main drivers”

Informant13 32:23 “also uhm. It increased also the workload for the data management team, because when we should be able to process the data but there are lots of data in real time. Uhm, so we had you to add more people into the data management team and unlike in the past. Uh, so while we saved the costs in terms of the data enterer, but we also increased the cost in terms of data management personnel.”

E.4 Theme: Lack of integration between systems, departments, and organizations

Domain: Barriers	
Theme: Lack of integration between systems, departments, and organizations	
Axial codes:	
Lack of integration	No enterprise-wide electronic health record systems are available in the public health facilities. Some localised solutions are implemented by departments, but not integrated with the organization as a whole
Data privacy and governance	The SA public health system encompasses different organisations operating in the same service delivery spaces, but sharing of clinical data between organizations and even departments are fraught with legal, bureaucratic and logistical issues.

Informant1 25:56 “I can't think of it of any, I mean just. I guess the lack of having a system altogether.No.”

Informant2 01:28 “OK, so there's definitely a need for I'll say databases, particularly within the clinical setting. We have patients coming in the admitted in. Data is collected throughout the duration of admission while in the hospital. So at the moment we only using one instrument, which obviously is available for free. And you know very well know a lot about it very well. And beyond that there isn't much. Although we've identified some issues with it, but for the fact of. The fact that there's nothing else available and we understand the importance and the value of capturing data, which is why we are actually using a REDCap at the moment.”

Informant2 04:56 “Oh yes, so it is actually possible to Electronically capture patient data on a day to day basis. It's just that obviously you need a user friendly software that will be well integrated and click on workflow so that even even if you know you have 10 patients, but you're still able to say OK, miss it. And then within maybe 10 minutes you're able to just capture you just click and you take in all the right boxes, but. Overall, in terms of the barriers, I would just say the fact that. We don't have universal data capturing systems across the helping help across the South African. Uh, South Africa as a country, so the fact that they not readily available and doctors move from one place to the next. I think that's the main barrier. The lack of availability.”

Informant2 26:53 “Yeah, I think for me in as much as we realize the limitations of our current government, but whatever software system that you're trying to implement, in as much as you know they're not reliable, we have to find a way of pulling them closer because it will be very difficult to convince the doctors and also and make it compulsory for everyone to collect this data without the involvement of the Department of Health, without the involvement of you know, government in

general, so you have to find a strategy of pulling them in, working closely with them and not against them, because ultimately the data actually belongs to the Department of Health, or so let me just say Gauteng or government whatnot, it does not belong to the universities. The universities are custodians and they have to, if they want to really integrate the data collection process with the workflow they have to bring in the comrades you have to bring in the premiers and everyone else who's a stakeholder and make them understand why it's important you know, just go down to their level and speak in terms of cost versus benefits and things like that, you know, just go down, stoop down to the level and bring them closer. It'll take you like many many years, but there has to be a way, otherwise you'll be frustrated along the way, especially because most of these infrastructures for data capturing they have to be within the hospitals. And yeah, so if you exclude them then you know there won't be much progress in that regard.

Informant2 31:26 “Absolutely yes. I would also have an issue if I, say arguments sake I work at you know Steve Biko, and the question is why should I be handing over data to Wits, I mean (…), unless if it's a consortium and I understand that there's a central hub, but whenever there's a need for me to try and retrieve this data, I understand that I can do that. And also for me I’ll want to know once Wits starts keeping all this data, what is the ultimate goal? Are you planning on publishing this data? And then if so, who would be the first author, who will be the co-author the, you know, the corresponding author in terms of the RINC funding and the and the and the allocation. It's tricky. Exactly so, so they need to know that they're protected, which is why for me I would want to start this whole thing coming from the top to say this is a South African project and this is how we plan or or we intend to structure it, but don't make it, for me I wouldn't, I would be hesitant if it's like if it's Wits only, I’m not saying Wits should not be involved, but just try and bring in other people. Even if they puppets. But the fact that they there, it will give others confidence that is not just the Wits uh, you know, project. Just to give you an example and the same thing happened with the Nelson Mandela Hospital. People were saying, oh boy, it's in the Wits grounds, but why aren't doctors from southern Africa invited? Why is it only Wits specialist? And then you know, that's why now there are issues, even though there shouldn't be any issues.”

Informant4 23:06 “Yeah, I mean. I think the big thing also is lab data, because usually what we do is again, everything is a little bit compartmentalized, so we have our source raw source documents, either either on a server. Uhm, that we scanned in or either in a file. Then we have. Basically a case report from data, whether that's on an electronic database, which it is, and it could potentially have a paper based version as well, and then we have our lab data and the lab has their own way of keeping their data, so I typically will download data from whatever it is, whether it's from our SQL Server, whether from REDCap and then you know get an email from the lab with their data dump and merge the two. If we were able to

somehow. Uh. Have the lab able to do that. Maybe if the lab were able to upload what they're doing on to the REDCap, that would. That would be, yeah, that would be ideal, I think, yeah. Or that would be like a huge huge step."

Informant5 28:36 "they're the ones then who who would have that interest in patient records. And the way that they gain access to that information is they have to go through the normal process. The HREC. But they also then have to go through another committee on the hospital side. And once they have cleared with the HREC, they then go through that channel, which will then grant them access to patient records.

Informant5 31:08 I think what what deters most of us in any type of research. The more effort required to get at the data. If there are more hurdles. And you know, there's that level of uncertainty as well because you embark on a project with this room full of uncertainties, and if you're still not guaranteed that at the end of the day, because you can waste a full year trying to go through one hurdle and the next. So I definitely think that if things were made easier or maybe. In the application process and. If they could streamline. The …. starting from ethics. You know if it would be one application, just this is just an example as well.

Informant5 32:13 "So I I, I certainly think if if in the streamlining of certain process, and especially for students, and it's even more heartbreaking when it's students going through that because I mean you need that to to complete your degree. So I I truly empathize, but even if it wasn't for students and for staff, but especially for students, if the whole process could be streamlined and. Maybe they just devise a way that you put in one application and it goes through all the loopholes. Once HREC has approved, they direct to the next ones and say here is our approval for candidates so … you know an everything just goes and you finally as the the researcher or primary investigator. You then get your …confirmation at the end of two months, but you know it has gone through all the steps and you're you know you're ready to just dive in and it would certainly help, and more people I think, would be willing to undertake those type of studies, and I mean you look at it and it's a mine of … information and data. I have no doubt that. There would be much to glean from there, and a couple of publications even coming from it, but I think the there are too many deterrents in that direction, so people aren't willing to to go through that painstaking process that rather go for some better. Easier way out.

Informant5 33:35 Even more than disappointing, disheartening, say you've gone through all these. Loopholes only get to an. I mean, we talked about that digitising and that also is done by people. It's will be imperfect. And who knows, maybe it was done by someone and they didn't do the task very well. The input some data, but they didn't put in everything that relates to that data. Some files were lost in the process, so with all this information that's put in there. As a an investigator, you

you finally get your approvals only get to to sift through the data and realize that. 50% of it is corrupted. You can really use it so that some more time lost you. You you now realize that you went guaranteed to get the data that you've just been given access to is unusable

Informant5 58:50 but I remember. Such things it's a pity that they sometime last year, though with these calls for virtual. Calls for funding for for virtual. Uh, projects? They involve data analysis and. And they were calling on different groups to not working in silos and to actually. Yes, yes, I know what you mean, yeah. And you know, and I found it interesting, and I I actually thought of a project, but I thought. Just the the process of networking itself. You know when you're a person with no background in something and you don't quite have the skill yet in this. Or the aptitude let let's say. But you're quite interested should you have had a connection to such and such a person who's interested in this type of research or who has access to this data. And who would have access to perhaps collaborators overseas or in some other African countries was thinking it would make for such and such a lovely study. So to say, you know, if things were pulled together. So I I guess point I'm trying to make is. Driving for, for those trying to. Uh, I know that the institution can only do so much that we also are. Cells have to propel ourselves and get the connections on and going, you know? But if there could be forums or. Platforms for for people to come together not just in that instance, when the funds have just come out and people are trying to find out what the funding is about. But if we could have those meet and greet type of things way before plan, I mean planning ahead ahead of time of such things coming out where people could. With different interests, you know an an introductory type of thing and. Yeah, where people could meet an forge and those with similar or aligning interests can then begin talking to each other.

Informant7 31:50 I think an an I think that the popiah act we need to unpack for ourselves and see. I mean, I understand it and I think it's important. But it's also important to see what risks lie in applying it totally.

Informant8 29:35 “Well, it's like for me it's it's crazy that we should be talking about should we be doing electronic data capture? and you know where we are right now? And I know you're a convert and you know that. But it’s like, why hasn't the university invested in this you know? Or government for that matter as well? I mean, it's so sad. Governments also put in the entire network to have Wi-Fi in in many places, but they don't make it (available). They haven't switched it on. It's not available to people, which which is, UM, such a waste of money and and so on, and why the two systems the Gauteng department of Health and the university systems don't basically talk to each other is also. Crazy, you know we don't have to have duplication of costs and so on. You can like they need to talk to each

other. If that could happen, I think, and that that would help us. I think in terms of quickly rapidly getting access of Wi-Fi to to people."

Informant11 03:04 "So REDCap I find it, so excel, what I like is that it's on my computer and I don't need to ask anyone for help. So we here at the NHLS, so even though I'm a Wits staff member, my laboratories and my team sit at the NHLS in Braamfontein and … we use the NHLS's intranet and Internet setup, so we all have NHLS email addresses and we use the NHLS network. And there's been a long standing problem for decades that the Wits and NHLS networks don't talk to each other. Uh, the NHLS has some sort of firewall and and you know we are unable to access Wits sites through NHLS. And when we speak to Wits they claim it's incredibly difficult. I think it's easier to solve COVID, than to get the Wits ICT department to engage with the NHLS to get us access to the Wits network. And when you speak to the NHLS, the NHLS is an instrument of government, so it's like speaking to The Department of Home Affairs or the Departments of Water. You really get the run around, but Wits has really shown no interest in trying to solve the problem for us. Uh, and so. Whilst REDCap is really great and it benefits a lot of people, it doesn't benefit us because our institution doesn't it necessary to support us. So I don't not like REDCap, if it's not available to me I can't access it, and so I like excel because it's on my computer, and I don't have to pick up the phone and beg anyone to do what should we really basic things. ... I can't articulate how frustrating it, I've probably been to about 40 meetings to sort out the issue of can I get access to REDCap? And like I said, it's easier to fly to Mars and to solve this problem"

Informant11 5:34 "In the space of 4IR, the Vice Chancellor is saying he wants to put a man on the moon. You can't walk the network down the corridor. And then you want to put a man on the moon. So I know it sounds a bit jaded but you have to appreciate that it's been 10 years that we've been fighting this battle"

Informant11 07:02 "I had a couple of students who are engaging with you. This was some years ago. PERSON NAME and others to try to sort out REDCap databases for our studies. And you opened profiles, but then we couldn't access them, and what happens is, the study doesn't stop, so the study keeps going on, right and what happens is you create a very big data vacuum because someone can't enter data, or data is collected, it's not checked, it's not entered, it's not QC'd, it's not anything in and you just need that to go on for a few months and suddenly you have stacks of paper that high, and then you introduce a huge amount of human error. And so we had all of this, you know, then they started entering the data into the database, and when we had it checked, it was like 17% of the data were wrong, 12% of the data were missing. Now those patients have come and gone so we can't go back. So so having access, you know, just coming back to that, it's really very central to how useful these things are so."

Informant11 32:49 “So like I think if the university wants to say it's embracing the digital revolution, I think it should stop ignoring the fundamentals, and the fundamentals is that this needs to be available. You can do electronic capture if you give somebody an iPad, but if you still give them a piece of paper and say, embrace the digital revolution, like it's a sign of madness, right?

Informant11 34:10 “So it’s a political and governance issue and the most influential political university in Africa can't negotiate that. Whatever the issue is, what I'm saying is that I'm I'm sick and tired of hearing the excuses. Like if you cannot solve a problem like this, you cannot ask me to take you seriously as a university or anyone else. So I don't want to talk more about it like it, it should be solvable right?”

Informant14 39:32 “One of the most important things to clear away would be the NHLS politics. Yeah, it's trying to understand what what's going on there and trying to find a better way for dealing with access to information requests from academia and elsewhere to the NHLS's database. You know, to try and depoliticize it”

Infromant14 36:00 you can tell how bad diabetes management is across the country. You can tell how bad HIV management is and every times company grows out the database, eoh throws up his hands and says, Oh my God, you know how dare you like show us how we are and and that is the problem? Yeah it's it's it's politicizes a database and it's difficult not to. With helps you know and so. Yes, so that's a tad requires some calm here. There's not somebody walking in and saying, oh we are you know we just wanna make the world a better place so it's it's much more complicated than that so it needs some Yeah, it does need some calm heads to be sitting in oversight committee.

Informant14 39:51 I think there's this vague idea that more data equals more action, and that's nonsense. We know our our both our private and public health care facilities are in terrible States and and public health is in a terrible state and somehow more data is going to help us is nonsense. You know, we we South Africa is just a wealth of wack papers and data sets and things and very little action. So I the cynical part of me thinks that this is partly a reaction to a recognition that we doing badly and like get back till I get the sense of wanting to do something. But there's also the academic thing here, which is more data will help us do more and it's like nonsense at this stage, you know.

Informant14 40:50 So it's so that's I think what they're trying to solve is they're trying to solve. A lack of. Direction and emphasis. And it's a misguided thing to my mind. I mean, I think that there are interesting things like we could look at and so.

E.5 Theme: Network infrastructure and capture devices: how am I supposed to do this without a tablet and Wi-Fi?

Domain: Barriers	
Theme: Network infrastructure and data capture devices: how am I supposed to do this without a tablet and Wi-Fi?	
Codes:	
Networking	Some rural campuses and public health facilities have no internet connectivity or have isolated LAN points but no wireless access. Broadband data costs are high in SA
Point of capture devices	Some rural campuses and public health facilities do not have computers or data capture devices. Where devices are provided, high rates of theft and poor maintenance are a concern. Bring your own device policies not compatible with low-wage earners like data capturers

Informant2 09:55 “I would say on my side it would be the capturing of raw imaging data because in in as much as they have PACS you still cannot access the raw imaging data and all that. You need a lot of cloud space, you need ample space to save that data, but it's still a requirement. I think it's not something that you can just you know overlook and move on and say oh we don't have enough space.”

Informant2 14:13 “and number three. It'll be perhaps things like access to data or Wi-Fi. If there's no connection, what actually happens? Does my work pile up, or I can use the system even when it's offline and there's no access to electricity? And also with issues like, you know security. What happens if this the iPad, the device that I'm using get stolen under my watch while I'm on call or it falls, do I uhm, am I supposed to pay for it? Am I liable? So those could be some of the barriers”

Informant3 18:00: “Uh. The one thing we do have. Is. If it is electronic and you do want direct, it sometimes is an issue it. So if you working at Bara or something like that, having the patients directly input the data on electronic media through electronic mail mechanism. So there we still probably go through a pen and paper route, so we haven't totally avoided the transcription error process for our problem.”

Informant4 08:00 “We just have connectivity issues. So to do an electronic entry, solely rely solely rely on an electronic data capturing system. You just. You know? Things go haywire when the power is out or the Wi-Fi is out, or there's the internets down.”

Informant4 31:43 “You know, I think one would be. Ah. More on the inside the server side. The speed of the server, so having making that faster and either hardware or personnel to yeah to make that faster because I will say that's

probably the one downside is we have this large or we store a lot of information. And so to make that faster”

Informant6 36:00 “For example an you know with the pandemic. Able to physically come here. I'm so developing digital repositories is something that's going to be crucial. I think going forward. Do we have the space? I've been struggling with it. I've got so many external hard drives that I've got around trying to copy information so that I can develop this repository. So this is something that the university definitely needs to look into. I know that some of them they are some ideas going around, but it really hasn't filtered down to our level as yet like, so I do think space for one is a major issue. Also going forward. Uh, but I also think it's a disconnect in terms of, you know, 'cause I've seen things on 4IR. Uh, in relation to the university and kind of their agenda, but this hasn't filtered down to us is, and I think ---- disconnect is not connected at some stage. Some will move forward, but you know the rest of us are just going to be set in behind the guy in like you know and so I. And in terms of the quantum computers supercomputers, I definitely think we require this”

Informant7 25:53: “So there are a lot of innovations coming out of 21st century learning for example. And we just don't have the hardware and the data systems to support that, so I think that's a huge need. If we're really going to seriously take on online. Uh, learning and online and data management in a big way. Then we need the, you know, the support structure for it and I think that's important and I think the university is aware of that, but um certainly I think, I think, that the the discussions with big industry players needs to happen so that you know where we shouldn't even pay for data. It should be a human right now. I think it should be something that everybody is taxed on and available. Even to my granny in the in the village”

Informant8 27:04 “So the biggest constraint, and I'm sure you'll hear it from all the others heads as well. The biggest constraint is just actually we don't have a very good infrastructure to do that right? And by that I mean that if you go to the (hospital), if I'm talking about the clinical, those spaces, so the (OWN HOSPITAL NAME) is like an exception in that we've got Wi-Fi here, we we are an exception. The rest of hospitals, even as big as Bara, you know they've got Internet connectivity in a few offices, academic offices. But throughout the campus of Bara, that huge campus that is the biggest hospital under the, for the university, there isn't Wi-Fi, which is in 2021? I mean, that's ridiculous. We had Wi-Fi here at (OWN HOSPITAL) since 2016 or 17 when we had the new building built. It did cost us money, but in the long run it wasn’t, you know it was well worth it. What what we paid. We had to pay from research funding. So I think when you go to the clinical departments the one thing they'll complain about is that there isn't the connectivity that you'd want for for people to enter, so that's … the one thing. Obviously the hardware that the university doesn't quite put in, you know you you depend on an

individual's personal computers and laptops and that sort of thing, so that makes it also harder because you need to have that infrastructure in place and say you know this is the infrastructure. It's there. The computers are there, it's networked. It's, you've got. And you need Wi-Fi, because if you're going to be collecting information you can't be running back to back into your office to put it in, you need to do it at the bedside. You need to do it everywhere and so that, I think is our biggest biggest challenge."

Informant8 29:35 "Well, it's like for me it's it's crazy that we should be talking about should we be doing electronic data capture? and you know where we are right now? And I know you're a convert and you know that. But it's like, why hasn't the university invested in this you know? Or government for that matter as well? I mean, it's so sad. Governments also put in the entire network to have Wi-Fi in in many places, but they don't make it (available). They haven't switched it on. It's not available to people, which which is, UM, such a waste of money and and so on, and why the two systems the Gauteng department of Health and the university systems don't basically talk to each other is also. Crazy, you know we don't have to have duplication of costs and so on. You can like they need to talk to each other. If that could happen, I think, and that that would help us. I think in terms of quickly rapidly getting access of Wi-Fi to to people."

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Informant11 07:02 “I had a couple of students who are engaging with you. This was some years ago. PERSON NAME and others to try to sort out REDCap databases for our studies. And you opened profiles, but then we couldn't access them, and what happens is, the study doesn’t stop, so the study keeps going on, right and what happens is you create a very big data vacuum because someone can't enter data, or data is collected, it's not checked, it’s not entered, it's not QC’d, it's not anything in and you just need that to go on for a few months and suddenly you have stacks of paper that high, and then you introduce a huge amount of human error. And so we had all of this, you know, then they started entering the data into the database, and when we had it checked, it was like 17% of the data were wrong, 12% of the data were missing. Now those patients have come and gone so we can't go back. So so having access, you know, just coming back to that, it's really very central to how useful these things are so.”

Informant11 26:54 “The second is you know you'll be surprised, especially in our peripheral sites. Things like you know where are we going to charge this thing? There actually isn’t any power in this room where we do…recruitment. We collect sputums and things outside. You know if this thing goes flat what we do? So there I think some some operational issues which are not difficult to overcome, but they are there

Informant11 27:13 “then the third is theft. And so these are highly sought after devices. And so you know the. Yeah, and and I mean we've had some in the field only a few weeks and they stole it. You know? So so I can't. That is a barrier that's a significant barrier, an iPad costs a lot. And if you give five iPads to a site in three iPads get stolen, you know this is not money that you can keep coming up with. So I think securing the the digital resources.”

Informant11 29:51: “And often like so, the one thing we thought about, and I think this would be a real game changer, is if the entire functionality could be captured on someone’s smartphone. And then it's actually it has to be _their_ smartphone, so it's one of the terms of employment you have to have a smart phone that can do these things. And then people look after their own things. They don't look after your things.”

Informant11 31:14 “And I hate to go back to this, but like is developing a network so hard? Like is throwing down fiber and giving all your researchers access to the Wits networks so hard? Is it this difficult? Because you know the and I did this I

was invited to do this course by the university for people they consider leaders in the university and it was called (COURSE NAME). And Wits is writing its strategic vision now, right? The it's vision beyond 2023, and it's all about, as I say, the moon shot embracing 4IR, you know, embracing the digital revolution, imagining the University of the Future. But you cannot get network to 100% of your researchers. Should that not be a fundamental thing? Like as I talked to you now, I'm using my cell phone, right? And my computer is connected to my cell phone because if we do Teams on the NHLS network it is so slow it will freeze and you will have to log on six times. And so I just I go and I buy 2 gigs of data every week”

Informant11 32:49 “So like I think if the university wants to say it's embracing the digital revolution, I think it should stop ignoring the fundamentals, and the fundamentals is that this needs to be available. You can do electronic capture if you give somebody an iPad, but if you still give them a piece of paper and say, embrace the digital revolution, like it's a sign of madness, right?

Informant11 34:10 “So it’s a political and governance issue and the most influential political university in Africa can't negotiate that. Whatever the issue is, what I'm saying is that I'm I'm sick and tired of hearing the excuses. Like if you cannot solve a problem like this, you cannot ask me to take you seriously as a university or anyone else. So I don't want to talk more about it like it, it should be solvable right?”

Informant13 38:55 “Yeah, you also need a good IT personnel because once you start using the tablets when you have like, like in our case. Currently we have like maybe 250 members of staff that are going out every day into the field, so that's the 200 a day tablets that you are sending out. You need to find a place where you are gonna charge them overnight. Overnight uh, and also just making sure that you are tracking the equipment itself. You need good systems. Otherwise today you have 250 tablets. After a week you are left with 200”

Informant13 39:47 Yeah, so when we started … we used to have a lots of cases where our tablets would go missing, and then we tried hard to put in systems. Uh, to uh to reduce that, and I think the systems we implemented, because we work, uh we have like a dedicated team of only two people that are actually issue with tablets. So every tablet that is issued in the morning we sign it out and then you will be a few teams come back we need to sign it in and then if it was signed it in and then it goes missing then we only have two people to ask what happened. Uh, yeah, but occasionally we do have, like one goes missing. Uh, maybe are you here or there was a contractor that came and to work in the server room and the UM? Somehow they were left alone and when somebody takes advantage and then he takes your tablet but it, is ah, at a smaller scale at the moment, but it does happen”

E.6 Theme: Fear: Change and technology is scary, and we already feel overwhelmed and under-resourced as it is.

Domain: Barriers	
Theme: Fear: Change and technology is scary, and we already feel overwhelmed and under-resourced as it is.	
Codes:	
Technology anxiety	Fearful resistance to technology. Perception that computing devices and data capture systems require “special IT skills” to operate. Linked to perception of differences in generational technology literacy or access to technology during childhood.
Fear of change	General anxiety or emotional resistance to changing from what is familiar, not just relating to the introduction of technology.

Informant1 05:17 “And I mean, it may be creature of habit. I think that's why many people don't change from what they used to, but I feel like with Excel, the more you get to know it, yoh, the you know, the more you just see the capabilities that it has.”

Informant1 17:06 “And I think a barrier for REDCap is it's it is daunting, and it seems like I know, (PERSON NAME) has spent so much time getting to know REDCap and she's fantastic with it. But that’s uhm, it's obviously you know. She was super interested in becoming very acquainted with developing these databases in REDCap. And I, yes I guess I don't have that passion and I certainly don't have the time and it feels like a it just feels like a mammoth task. And I think that's, definitely I mean we all busy, but certainly for for the training surgeon and for the consultant surgeon, like figuring out that is. Yeah, it's it's the fact that it seems daunting is something that you just rather not. Just don't have time.

Informant2 13:55 “So in my view, it will obviously be time, people may feel we don't have time. Number two it'll be the lack of computer skills, other people who are probably a little bit older. They may feel we’re a bit technologically challenged and therefore we not eager to do this”

Informant4 29:14 “You know what I think? In my experience, it's just exactly what you said. If this is what you're using and then you keep going with it. Because especially it, especially if a unit, has been using has been, you know, has one system of doing things. That they kind of just adopt for every project. Changing that whole system is very scary. Uh, nobody wants to change just for fear of things that could go wrong. I guess change in any circumstances scary, so that would be, I think. Uh, just a hesitancy to change.”

Informant5 42:53 So it would then take more time from me, which I I don't think I have, but. Look at as I was trying to see how to familiarize myself with Atlas TI I I

could see that I can import. An expert, so maybe importing it I I don't know how much I haven't done it, so I I. I don't really know how much more time I would need to put in or if it would really take it in and. And. You know, uh? But I do think it's it's time I don't have so.

Informant6 07:42 “Yeah, so the first part I think is, in my opinion I think it's generational. Uh, I think I just, uh, it was my younger colleagues or peers within the school, uh, I think they're more tech savvy, you know? So I was taught an excel, that's how I was, my development started with that, so I'm more comfortable with it. Uh, you know and then. So I think it there is an aspect around age that you know and when we were exposed to the (system) and what was the foundation basically so that was my introduction was on Excel and so I feel very comfortable utilizing that. But also I don't take much time to explore other technologies so you know that's another, but it's more of a personal issue that I really need to, uh, play catch up with.”

Informant6 14:32 “It is also a level of trustworthiness… it’s not with REDCap, it took me awhile to get onto Internet banking. I always felt that I had to deal with the individual so that I could hold him personally responsible if anything goes wrong. So I think also with my own mental change to technology. Just trust in the system or something that took me a while to to acclimatize to.”

Informant6 32:55 “there's catchphrases, uh, now that you are speaking about that, (INTERVIEWER NAME), is that I mean even the word coding to me always, I have resistance immediately, because I'm, you know, it's like I have to learn this new language. Or you know, and it's very complex. And only IT guys have this ability. And this computational kind of frame of mind. And this type of thing. But I don't think. It's that, ah, (difficult) don't get me wrong. I do think there is complexity and some of it, but I think in some cases we over overly. You know, fear, fearful of the system based on the words, because we don't have the understanding of what's actually entailed. So if you know if that information could be broken down a bit easier, you know to say, well, code is not anything you should be scared of. It's actually something very simple, and here's a simple example of it. I think that might help people to overcome this barrier.”

Informant 7 13:11 “But I think generally people hate filling in things. Uhm, I don't mind data, but I mind forms of any sort. And which is a kind of data I guess, yeah, but you know so I think just the time investment is a lot for people and the fear of inaccuracy is what stops them”

Informant7 21:27 “You know one person described something to me. She said it's like being in a very little ship in the middle of a hurricane, and you have been tossed and turned, and you are working until late hours because you first have to

learn, then do it, then deliver, all in that space. So imagine if we'd, and then they would actually get in touch with (PERSON1) or (PERSON2) or (PERSON3), at all hours of the day, and if they didn't have that hand holding. It would have been impossible and we would have had a disaster on our hands, as I believe some schools have had."

Informant10 04:54 And yeah, I think I think probably the biggest thing is just it's there. You know, that's that's what's familiar and what's common, and what people have always used it was there when I came into the post. Excel Wizards and they can do magic with this thing, but I can't profess to be one of those. I just, you know, I think I've got a. I've got a fairly good grasp of it, but it's it's very generic, so yeah.

Informant10 30:50 Uh, I think I think you need to offer training. UM, the organization needs to offer training and support and there needs to be an avenue where when people are frustrated and they're just, you know, can't figure out how to get it done, that they they, there's someone that they can go to who will say, don't worry, I'll hold your hand through this process and you know, we'll we'll figure it out together because I do think that that that's a big part of it. People people don't like change, they're afraid of change they're, you know. They're very reticent to try something new, so if there's someone there who will hold your hand through the process and show you that it's not as bad or as difficult as you think it is I think that is a big help".

Informant11 26:14 "I don't actually believe it's a literacy issue. It's actually a fear issue that that people know how to use their smart phones, in there. But when you present them with this iPad, and you say, what you've been doing in paper now you do it like this. There's just an anxiety associated with the adoption, and I just think that that's all it is. It doesn't have to do with literacy, competence or anything, it's just the anxiety and. And The thing is, most nurses and people who are (…) in the field, recruiters, nurses, data captures are very anxious when it comes to the CRF and the primary document, because that is gold. That is the Bible and now you telling them we changing the Bible they you know there's just just so I think there's a. There's a lot of anxiety associated with that"

Informant11 34:36 "You know, I feel … there is this anxiety associated with digital and it has nothing to do with literacy or competence, right? I just feel like you know there are, there's a large group of people who are intimidated by this by this technology and and really, we need to bring everyone to a space where they comfortable, you know. And I think having heat drives some of these heats where one whole week, you know we have all these devices in the canteen and everyone can come at any time and there's someone in front of a device they'll tell you what

it can do it. They'll tell you how it can help you. You know like I think people just need to start engaging with technology"

Informant12 32:15: "and I think actually once he realized it wasn't as hard as he feared, because I do think there's also this thing about something new and and having to learn a new thing. And so there's resistance around that. But once the barrier was broken around around, actually I can do this. It's it's. It's not difficult, it just requires a little bit of of thinking and and you know, I mean with those we don't even have skip patterns because basically, you know, sort of everybody gets asked every question."

Informant13 31:21 "Why don't we challenge is that we we we we faced when we moved to be electronic system? Once they have a field worker being used to writing on paper so to transition from writing on paper to capturing it on the tablet. It was a little bit challenging for some of them. We actually lost some of whom we all. The field workers that we're good on paper. They struggle DTR Arturo to use B tablets. And we we we have some that are actually in the earlier days will actually copy. The responses are in a small notebook and then they are transcribe later on into into into the tablet. Like, no, that's not what you should do. You should end up with data straight in your into the tablet, so it required a yeah, a lot of training on on on the field workers."

Informant13 33:17 "if you're just starting is so easy to adjust your mobile strategy into electronic. But if you started with a paper based system and there's also just the resistance to change among the team to say no, is this gonna work? Uh, and you like with this surveillance, everybody is worried that if you introduce a change is gonna affect to be surveillance and they will still have. At the moment we're still trying to. Do it systematically"

Informant14- 30:01: "you know I'm a doctor. You don't want … to trust me with database design. And yeah, like REDCap, I made my peace a long time ago that I found excel really hard … I tease my staff all the time. About you know the two kinds of people in the world. Those who love excel and normal people. And and there's I feel the same way about REDCap and all the other systems I've had…all sorts of various attempts to try and train me"

E.7 Theme: Ease of Use: Misalignment of time/effort and motivation. When we say ‘too difficult’ we mean ‘not worth the effort’

Domain: Barriers	
Theme: Ease of Use: Misalignment of time/effort and motivation. When we say ‘too difficult’ we mean ‘not worth the effort’	
Codes:	
Time and effort	Reluctance or a sense of being overwhelmed is expressed when speaking about the time and effort it takes to learn how to use a new technology, using technology takes longer than the process it replaces. This resistance is reduced of the user has support and directly benefits from the system
Instrument complexity	The complexity, intuitiveness, or ease of using a data capture system is cited by most informants as a reason to adopt/abandon. The level of “ease” seems heavily influenced by the users’ perception of benefits/relevance to themselves. The less a user stands to gain from a system, the simpler their interaction with the system must be
Motivation	Motivation influences users’ perception of how easy it is to use. Researchers or managers have an interest in having access to aggregate data in order to perform their duties, and are more highly motivated to adopt electronic data capture. Clinicians and nurses are often tasked with capturing electronic patient information, but doing so is not perceived to benefit them in the performance of their primary duty to delivery clinical services to patients (or in some cases, it is perceived to detract from their primary duty).

Informant1 17:06 “And I think a barrier for REDCap is it's it is daunting, and it seems like I know, (PERSON NAME) has spent so much time getting to know REDCap and she's fantastic with it. But that’s uhm, it's obviously you know. She was super interested in becoming very acquainted with developing these databases in REDCap. And I, yes I guess I don't have that passion and I certainly don't have the time and it feels like a it just feels like a mammoth task. And I think that's, definitely I mean we all busy, but certainly for for the training surgeon and for the consultant surgeon, like figuring out that is. Yeah, it's it's the fact that it seems daunting is something that you just rather not. Just don't have time.

Informant1 18:28 “Oh, there is a massive. These are massive massive need and this is exactly at like we feel. We need a designated data capture and er Uh, we are currently literally trying to see where we can release funds to employ a data capturer, because we just again (unintelligible). Time consuming. No, we are actively pursuing getting a designated data capturer, and that in any way not solve

the problem across the board. This will solve the problem for us in the (RESEARCH UNIT NAME).

Informant119:46 So I mean, just thinking further than just data capturing. We also are putting together, we've actually put it together, a motivation to the Dean to set up like a Research Institute at the various hospitals. Well we specifically obviously had Bara initially, 'cause that's where we have such a great patient cohort. But yeah, to have everything together like a research nurse, so we on top of all the clinical and demographic data, data capture, making sure all is there, a technician to immediately analyze - processed samples, not analyze, process samples. So yeah, just a team working together, but I I think even if we can have a designated data capturer or two for, just you know, Uh, for for departments that are doing a lot of studies. So to have that person at Bara, and to have that person at Charlotte, so we know the data is being captured and if anything is missing, this person is going to follow up. So only other thing obviously is these hospitals need electronic patient records. That would also solve a lot of problems in capturing data you know, rather than going through all the files with missing, you know sheets of blood results and it's just yeah"

Informant1 29:16 "Struggling with it like not knowing where to click what, or you know you're not, if it's not user friendly enough or just yeah, self explanatory. You know we all like I said, we all live in this world where we are all busy and you know you'd rather just use what you used to because it's quicker …than something that is not user friendly and I'm not saying you know REDCap is not user friendly or whatever. Struggle, I know. I'm just thinking what would be reasons to not, yeah, adopt something."

Informant1 30:22 Yeah, you know I I think uh, the simpler the better obviously. It's great when it has so many bells and whistles. Anything is great with many bells and whistles, but yeah, to get your head around how to, you know use those bells and whistles, that's I think and and yeah again, I think if. If it's maybe, like I said, those those targeted like info sessions or just you know how to like, we've changed our research course to have a lot of how to things were things that people keep asking us like how do you use your automated referencing system and we just have a practical. This is how you do it like it's 15 minutes quick and easy, but it's a how to session so maybe somehow two sessions, maybe even just webinars or. Things like that that would be that would be great. Actually, where you can look at it in your own time and you don't have to, you know, go and attend a three day course or. That's what's great, for example, I use STATA for statistical analysis. And I tell you there's nothing that you cannot get a YouTube video on to explain what to do in STATA for a particular test, it's amazing. They have a designated YouTube channel for their, you know they training. Yeah, and I think that would be nice, maybe even just in your REDCap, you know, have a REDCap website for

Wits and have short little tuts. If I'm ja, REDCap specifically, you know we all are acquainted with Excel, and I think that's also for ease. You know your supervisor knows how to look at your Excel document.

Informant1 33:50 “Yeah, I mean, I think the bottom line for me is ease of use would be the driver and obstacles or not being user friendly would be the barrier.”

Informant2 04:56 “Oh yes, so it is actually possible to Electronically capture patient data on a day to day basis. It's just that obviously you need a user friendly software that will be well integrated and click on workflow so that even even if you know you have 10 patients, but you're still able to say OK, miss it. And then within maybe 10 minutes you're able to just capture you just click and you take in all the right boxes, but. Overall, in terms of the barriers, I would just say the fact that. We don't have universal data capturing systems across the helping help across the South African. Uh, South Africa as a country, so the fact that they not readily available and doctors move from one place to the next. I think that's the main barrier. The lack of availability.”

Infromant2 07:52 “so in (DEPARTMENT NAME) they are using Microsoft Access which is obviously in all the system. It takes longer to use but the people that are meant to be actually responsive for capturing that data would be the register as a rotating in (DEPARTMENT NAME) and there is no allocated time for capturing the data. So in between maybe they calls or when they're not covering the wood then that's when they expected to sit down and capture that data.”

Informant2 08:40 I think our priority we have to take put things into bed into perspective. The fact that if you would work between 8:00 and four, we've signed a contract with the government and their priority is service delivery. So as it stands, service delivery will have to be a priority. And in between everything else then we'll just have to sit down and type those reports. I mean I remember in nuclear medicine it doesn't take long. If you saw the patient because you just kind of writing down with you. They did not. You so, so there is a way around it. People just need to be more against organized and you know, just plan ahead. If it means you coming in an hour before work starts or in between the patients you do your typing. I think you know that's the only way, but we can't now put data capturing above the needs of the patients.

Informant2 13:55 “So in my view, it will obviously be time, people may feel we don't have time. Number two it'll be the lack of computer skills, other people who are probably a little bit older. They may feel we’re a bit technologically challenged and therefore we not eager to do this”

Informant2 14:00 and also. I guess. OK, OK, I think we mentioned time experience. I mean just lack of interest in laziness. Some doctors are just arrogant like that. You know, just want to be like, no, I'm not interested. I'm here to see patients an OK. It's just like Lego world. An understanding of the bigger, you know, benefits for doing this.

Informant 3 09:26 “I'm as I said the this the SIMS system, just not user friendly. It seems to have it so I don't know how people would data into The Sims that's done by the administrators. I don't know where it gets done or hard gets done, but the data seems to end up there. As I said previously, the the issue is getting hold of the data you sent. You have to do it manually as far as I know, that's the way we've been using it for since Sims got introduced. Uh, having a secretary go in, get the data for the school, put it out one by one the records, and then put it into a spreadsheet which, when you've got a lot of post grad students, becomes a every tedious task to do attain.

Informant5 22:59 “I felt the ease of use of the others, where they, outweighed that of using REDCap such that if if I compared the difficulties, I would have to go through with REDCap it it. It didn't seem justifiable, and you know, we always try to take the easier route if we can get the same outcome.”

Informant5 23:29 “So really it as much as I am interested in fully understanding and knowing how to use REDCap. I guess one it was the ease of use, two I had limited time to really get to understand it, but the others were fairly easy to grasp for me. I I recall that with the Microsoft one it took me 3 minutes and the person was just telling me this is what you do. Thought it was so easy. 5 minutes for the Google One and I thought it took me 3 minutes with the other five minutes with the other. Now REDCap I'm having to try understand this for over 30 minutes. I I don't have the time, you know. Yes so. Yeah, so time constraints is another factor”

Informant6 29:17 “Yeah, so it's really the user friendliness of, you know, I know we've been, for example, we've been forced to use online teaching now and we've jumped from Sakai to Ulwazi and all of these different factors. And I mean I can speak to it from that perspective. Is that if it's not user friendly, I'm going to be very resistant to using it for myself. Personally, I find again, I'm not sure if this is a age thing or personality thing, or find some colleagues are. Very motivated around trying to figure out a new system. I I'm not drive and in that way at all I I just want something that you know I see it as a tool and I need to use this tool to get to a specific point. And you know whether it's research or teaching or whatever it is and the easier that tool is to use for me personally in terms of using user friendliness, I suppose that's my drive. Uh, around it and my limitation would be if it's too complex”

Informant6 30:30 “Uh, around it and my limitation would be if it's too complex, so like for example the language thing. With this I think it was HTML coding or something that you were using in there. Uh, so after our second meeting I had another problem. Uh, but I just Googled HTML coding or something around that and I was able to figure out the issue immediately. Yeah, so, but I I didn't know it was that easy. Otherwise I was I didn't want to. I felt so bad about calling you. OK 'cause I do, you are busy so I told him we just try and figure this thing out if I can in my own. So I suppose it's also having a bit of an answer. I mean just having this drive to try and exploit. But the easy as it and see, and I think that is it can see, comes with a fear that it's more complex than what it really is. And it wasn't really. It was just a very simple thing that I could pick up and. You know, so I don't know. I suppose it's a learning curve as well, and maybe we you know, as the more we engage with the system, the more confidence we get from it. And in terms of problem solving, you know as we go along”

Informant6 31:41 “Yeah, and I think as humans we basically just go for the easiest, right? I mean, I think our brains are wired that way like.”

Informant 7 13:11 “But I think generally people hate filling in things. Uhm, I don't mind data, but I mind forms of any sort. And which is a kind of data I guess, yeah, but you know so I think just the time investment is a lot for people and the fear of inaccuracy is what stops them”

Informant7 15:56 I think you know the very nature of Wits is very technocratic. So people pay attention to their area of expertise. And they don't connect it to the data. So they find data as an added burden, except where it inputs into their technical area of expertise. So I think that's one reason. The other one is people are just poor planners, some of them. And they prioritize other things. Uh, and you see it, a person who's a good planner, and works and and makes sure that they deliver. They will always give you data no matter how busy they are, and then other people just lack the interest really.

Informant7 21:27 “You know one person described something to me. She said it's like being in a very little ship in the middle of a hurricane, and you have been tossed and turned, and you are working until late hours because you first have to learn, then do it, then deliver, all in that space. So imagine if we’d, and then they would actually get in touch with (PERSON1) or (PERSON2) or (PERSON3), at all hours of the day, and if they didn't have that hand holding. It would have been impossible and we would have had a disaster on our hands, as I believe some schools have had.”

Informant7 22:24 “I am so exhausted with the number of new things that come up because I just learn one thing, and then I've got to add this, or they've changed the platform or and I don't have time to learn that. Let me settle in first.”

Informant7 24:13 “You know, with with the increased a turnover of technology, you you then need somebody to come and say, oh, this is new, just add this and that and then your work is facilitated. Otherwise it just becomes a pain and and from that perspective the university must decide on the learning management system and stick to it, irrespective of its problems, because I'm absolutely fed up with starting with Sakai, we had Moodle, then you know, now it's a Canvas. We better stick to canvas, otherwise they're going to irritate the hell out of all of us.”

Informant8 06:10: “Uhm, what attracts me most do it then and even now is the ease at which one can create the form. So it's a very. So be user friendly system that's been designed where … I can create a form within minutes you know, because they've got all these options of the the fields so to to to navigate around it. And even if even though I've been using it for years about to show it to someone and say, you know you could do a form within within an hour, they'll be amazed at how many options they have and how, how simple it is to to to put those. Various fields in and, so that's …the biggest attraction for me”

Informant8 10:59 “I've also been for training some time ago, but because we had a data capture, I said, you know, do the fields, set it up and let's run with it. And then he left, you know, after two years his contract ended and he left. And I felt at the time you know there was an urgency to get the form out and I I didn't have kind of the energy to go back and start relearning REDCap and versus here's something that I'm used to every day so you know, in fairness I wouldn’t say there was something really bad with REDCap, and that was why we went with Formbuilder, it was just because it was more comfortable for me.”

Informant8 15:00 We also ask our interns and medical officers that when they're capturing information about an admission and so on, thet they put it onto REDCap. That's not a great because you have many people and there's different levels of motivation, and it's it we always fall behind”

Informant8 22:55 “And so I went on to it and I … tried to create a form and played around with it and I really struggled. I just didn't. Maybe, you know, you become very comfortable in what you're using. But I'm willing to try, and I'm willing to… be challenged, but it was so clunky and I don't know. It just … seemed too many steps to get to do to do what I wanted, that I found it. I gave up Limesurvey, even though the biggest attraction was that it was free, you know, and but it's still. I was prepared to pay for something that was a lot easier to use than to waste a lot of time. So that was my one example, of Limesurvey, and maybe it was if somebody

just taught me how I would have had a different experience than trying to teach myself”

Informant8 23:42 “Uh, maybe I was like impatient, but I think that will be the deal breaker is that, is it gonna take a lot of time for you to learn something and not feel you know, you've wasted a lot of time, you know you, I think one is prepared to spend money just to save a lot of time. Because especially if you're going to keep going back to it, you want a system where you can keep going back to it and create another form and another form, I feel.”

Informant8 28:47 “the second I think is the lack of dedicated data capturers, which is obviously a big (one). Cause we’re relying on people to just fill it in like the doctors and nurses and so on. There isn't a great motivation, …to do this and so they won't do it very well. And half-heartedly and grudgingly. And so it doesn't become good data. You need data capturers to enter it and you also need data cleaning and so on”

Informant9 03:26 I mean clearly one place where one does need it is in in the practice, but I've never. Translated my practice into an electronic record logic because you know the. The the practice has been small and it's not being an area that I wanted to spend the time on to to to develop. So I'm still use a paper based system for my consultation.

Informant9 15:43 And you force people to do it, but I must say that. It reminds me of the days when when we started off in. In the (UNIT NAME). Forcing people to record discharge summary. And and I can tell you, I used to sit at 3:00 o'clock on a Friday afternoon when everybody was ready to go to the pub and and argue with the guys about what they've written in and discharge summary. So we had to go through 30 discharge summaries that week. And and you know, I would expect and then we had a typist at the time, and they had to record this. And I mean at least just value. And and it was because it was. Yeah, I was forcing them. They were not interested and they wanted the beer and. And and and we in fact eventually gave it up because it was an effort that had no outcome whatsoever

Informant9 17:09 . “I mean, one of the things that I think might be of some value at some stage is that, uhm, we enforce as from the Health Professions Council some form of audit of practices. Yeah, people will do it begrudgingly, and and I know that you know an angry person putting data in will give you an angry outcome. But you know the fact is, is that at least, yeah, poor data is better than no data. I accept that good data is a lot better than poor data but that. So, so I think that those are the drivers.”

Informant9 17:48 What makes me spend time putting data into a computer is interest, and you know whether that's my financial interests or whether I have this wish to understand what's happening around Covid, yeah, or you know whether I follow the rainfall pattern in (SUBURB NAME) in Johannesburg, you know. But I mean, …, there has to be something that you bring out.

Informant9 19:50 “ease of use and ….usability. … they are two components to that in my opinion, so one is obviously the, you know, that … it's intuitively easy to do but the other which is an area that I've learned over the hard time is security. I mean. And that is yeah. Uhm, how well the program performs and how often you lose data.

Informant9 23:07 Well. Uhm, (INTERVIEWER), I think that there's there's one, well there’s two statements that I think we've learned. And I mean, you know them as well as I do. The one is that you have to integrate it into making a person’s life easier. Uhm, and the moment it becomes additional, it's just yeah,… a total disaster

Informant9 34:26 So there's one player where one can go there and then, that is, there's an electronic medical record. Now … the risk that one has with an electronic medical record is, … is that there's a concentration on something else other than what we're doing at the moment, and … that it’s very easy to be detracted from that, so we need to not take that into the clinical environment, but it would be bloody interesting to find a way of, while one is engaging like this, that one is in fact also able to very quickly record some of the information that comes generated after that.”

Infromant9 “Then the more intuitive something is the the more likely it is going to be adopted. Because I mean generally if you need support. It's going to be. Yeah, invariably at the time when you can't get it and then it either gets shelved or in one walks away in disgust.”

Informant10 11:00 And that's what we were trying to do. I can't say that it's been a massive success, you know, because. Uh, I also think you know people get busy and they they they for gates and you know they they like when you when you emailing a student or you emailing various people to sort out and issue for a student you know then to think I must go back and, you know, make a copy of that or make a summary of that and put it in the students file and you know it's just. It's an additional like logistical burden that they you know it. It falls off, the IT comes off the radar a little bit, so that was the intention, but it hasn't quite worked out.

Informant10 14:44 Yeah, maybe, but I I do also think that, uh, you know, going to find the information is 1 issue but but the bigger problem was people putting their

information in, you know, actually recording that information because you know people are like I say people are busy. They get that they, they've distracted with 100 other things and it's just another thing to do. And you know it's it's tedious and and it takes time and so it falls off the radar a little bit and people are not always that good at keeping keeping those files up to date.

Informant10 26:15 Uh, I think that they they do it, they'll be willing to take it on if it's easy. If it's easy to understand if it's user friendly. If it's not, you know extremely complicated, and if they don't perceive that, it's that it's adding more work and more, taking more time to do than what they're currently doing, you know. And so and then, and conversely, those are the reasons why they won't. Because because if they think that it's more difficult, or it takes more time or it's going to be an additional burden, or it's a parallel process and they have to duplicate work. They're not interested.

Informant10 31:33 “but I do also think that there's a time element to it, you know, because as I say, what we found is that people are really reluctant because they think it's an additional it's yet another thing on their list of tasks to do that they've got a complete and they just don't have the time to do it. You know. So if they … along with offering this training and support, there's got to be some way of …. offering time off, protected time, for people to be able to adopt those processes until it becomes integral to your workflow and it's you know it's just part of what you do and then then it's easy, then you know it's just part of your day

Informant12 38:27 “number two then would be how complicated are, is the build. So is it something that I need to have to be trained to do? Is it something that I, and how long is that training? Can I reach a sense of being able to do it after, you know, sort of, a couple of, you know, sort of like days or hours or whatever? Or is it something that's going to take a lot of training and and and input in order to get to a point of mastery?”

Informant12 42:11 “Yeah, and and I guess and so that would be a little bit like a student. If we were to really sort of have our student records like fully and say for example on Redcap, our tracking of students which which it isn't yet fully, I would say from beginning to graduation you know from first registration to graduation that that if we were to do that. Yeah. I mean if we were say for example initially capturing. On another system, like on on Excel or on paper, then somebody would have to capture it into Redcap and that is time consuming so and so the fact that we we we do the tablets and the direct data capturing which actually I don't see why that couldn't happen even in clinical settings with the right support is that is that we could have, you know that did that that would require data captures so. So the fact that that we have gone the route of the of the mobile app and and doing data you know, like not having that extra step has has really sort of meant that that

we've saved that cost, but but I do understand in some settings that that there would be an effort and and either it would be an effort that is borne by by one of the research team or or that is borne by like or we would pay for the for that kind of support.

Informant14 13:10 “I will give you one just caution, big caution, because I've been involved in this field for 20 years and I was listening to the discussions and things. Everyone’s enthusiasm. There's a world of pain waiting for people who think. Doctors and nurses are going to comply with medical records keeping.”

Informant14 15:40 “I think the idea of a discharge summary that does come from the university is an interesting one, but I do think that you just need to modify your expectations and don't listen to the public health department. Do not listen to the IT department. Do not listen to the Deanery. Listen to the physicians and the surgeons because they and the nurses because if they tell you it can’t be done, then it won’t get done”

Informant14 13:50 “I recognize the importance of collecting data, but I also recognize that the people asking for it never feed back, and secondly they don't understand how much work it is and they're asking the most expensive, it's not just that the busiest, but also the most expensive people to collect.”

Informant14 30:01: “you know I'm a doctor. You don't want … to trust me with database design. And yeah, like REDCap, I made my peace a long time ago that I found excel really hard … I tease my staff all the time. About you know the two kinds of people in the world. Those who love excel and normal people. And and there's I feel the same way about REDCap and all the other systems I've had…all sorts of various attempts to try and train me”

E.8 Theme: Promotion and support increases familiarity, reduces fear and demonstrate benefits

Domain: Enablers	
Theme: Promotion and support increases familiarity, reduces fear and demonstrate benefits	
Codes:	
Bridgers and champions	Early adopters within the organization provide evidence that the electronic data capture is worthwhile investing time and effort in. Citing technology used to produce reports or research outputs during academic or leadership meetings important
Promotion campaigns	Top-down support and commitment to preferred electronic data capture tools must be regular and widely signalled
Technical support	There must be knowledgeable, contactable “go-to” individual/team who can answer questions, troubleshoot or provide expert consultation services
Familiarity	Users keep using the systems that they are familiar with, either because they were taught on it in school or university or because the department they work it is already using it

Informant1 06:42 “And I. I mean, it may be creature of habit. Think that's why many people don't change from from what they used to, but but I feel like with Excel. The more you get to know it, yeah, the you know, the more you just see the capabilities that it has

Informant1 31:48, it's like you know we all are acquainted with Excel, and I think that's also for ease. You know your supervisor knows how to look at your Excel document.

Informant1 11:00 So we find that quite useful. And it was basically started. It was initiated by the research quarter coordinated before me, so I just actually carried on with it. So that was basically the reason reason.

Informant2 15:20 “I think there will have to be, obviously, a campaign. You know, before you even launch the software. It'll just advertise and market the benefits and obviously highlight the various as well. But with an intention of making people aware that you know we are all aware of the limitations of, you know, moving to an electronic based system but at the same time these are the benefits for the doctor, for the and for the patients and also for the community or country as in general. So there has to be people that go, maybe from hospital to hospital talking about this, and highlighting why it's so important to just transition from where we are to where we going”

Informant3 03:00 “because the amount of data that we using the type of data we using and because people's familiar familiarity with it most the time we use Excel.”

Informant3 21:25 :F or my own. Experience there's push and pull factors. The the push is normally when your current. Situation, your current way of capturing and storing data is no longer meeting your needs. Uh, so you get pushed onto a new system, which is more capable. So for example, moving from Excel, it's not no longer serving your needs, so you move onto REDCap. The pull is. If you can sell it to the person that very early on so you get them to adopted before they become entrenched in the old, let's say using Excel, so selling them the the virtues, the benefits of using something like red cap. So there's the forced migration and there's the. He enticement mechanism I suppose for getting people to use it. And I know the faculty runs lots of redcap workshops. Uh, but workshops build familiarity with a tool with people that already want to use the tool. Uh, I'm not sure if it's a way of enticing people onto the tool using the tool, and I'm not quite sure how to do that.

Informant4 30:22 “I think having somebody with extensive experience in what I, a new platform or a new way of doing things, uhm, helps. And is would probably be kind of the only way that we might change these big or make these big changes. Yeah, having someone say OK, I've done that before, I've used that before, I can run with this, yeah?”

Informant5 44:02 I find your question difficult and I tell you why, because even with this Atlas TI. I could have easily missed it if someone hadn't sent it my way. He, uh, you know some of this information doesn't circulate as well as it should, so I think that's the first point there. If the institution is going to. Subscribe to some. And two out there. And make it available to to its staff. I feel there should be transparency a whole lot more of the researchers should know if there could be like on the one of the intranet sites like tools that they have and whom to contact and for what software you know. So I think that's that's definitely one.

Informant6 15:52 “You know, from my own experience I I yeah if I if I didn't have access to you, and the wealth of information you usually provided us with within the school. (PERSON NAME) as well, I mean he is IT, so you know, he also was very much a support system or base for us. Uh, it would be a incredibly difficult, I probably wouldn't have gone with that system to be honest with you, (INTERVIEWER), if I didn't have a physical individual that I could speak to and also complain to and also get advice on how the system, and reassurance, that look it is working. You just have to, one or two bugs is that needs to be fixed up. So I do think that. Yes, that physical interaction of an individual is really quite significant.”

Informant6 17:01 “And she’s also not, she’s in her seventies, she’s not tech savvy, she struggles with it quite a bit, but the reassurance of having this administrator

that she can always go to gives a lot of surety in using the specific system. And I think this is probably what differentiates it for us in comparison to like Google forms and this type of thing is that you don't actually have an individual, you know, that you can go to. I mean sure you can go onto YouTube and check a couple of tutorials to try and figure it out, but I do think the personal touch of having a an actual person there does does assist positively."

Informant6 30:25 "so like for example the language thing. With this I think it was HTML coding or something that you were using in there. Uh, so after our second meeting I had another problem. Uh, but I just Googled HTML coding or something around that and I was able to figure out the issue immediately. Yeah, so, but I didn't know it was that easy. Otherwise I was I didn't want to. I felt so bad about calling you. OK 'cause I knew you were busy so I thought let me just try and figure this thing out if I can in my own. So I suppose it's also having a bit of and that's what I mean just having this drive to try and explore it. But there is hesitancy and I think that hesitancy, comes with a fear that it's more complex than what it really is. And it wasn't really. It was just a very simple thing that I could pick up and. You know, so I don't know. I suppose it's a learning curve as well, and maybe we you know, as the more we engage with the system, the more confidence we get from it. And in terms of problem solving, you know as we go along"

Informant7 19:34: Absolutely essential, I can tell you that as a school we didn't have as many problems going online, for example as other schools. In irrespective of the fact that when (PERSON NAME) started, I mean I was here at Wits already. And I'm a person who's got an appetite for learning new things, so I will, I took interest, Uh, I think we were incredibly lucky to have somebody who has the patience and the thick skin that one requires, because if it was somebody like me I would have said ag, bugger these people, they're not interested

Informant 7 21:00 "people said first of all it was a huge steep learning curve for them. But being able to have a go to person was really, really important and they really found it useful"

Informant7 21:27 "You know one person described something to me. She said it's like being in a very little ship in the middle of a hurricane, and you have been tossed and turned, and you are working until late hours because you first have to learn, then do it, then deliver, all in that space. So imagine if we'd, and then they would actually get in touch with (PERSON1) or (PERSON2) or (PERSON3), at all hours of the day, and if they didn't have that hand holding. It would have been impossible and we would have had a disaster on our hands, as I believe some schools have had."

Informant 7 23:03 “I think they're absolutely essential. Having a good go-to person is important, until we get to the point where this newer generation comes in and they don't need that. But at least while you've got a mix of people come from a different generation having, uh called, you know the the early the middle and and the late, which is us. You will have to have people like that in this system.”

Informant7 24:13 “You know, with with the increased a turnover of technology, you you then need somebody to come and say, oh, this is new, just add this and that and then your work is facilitated. Otherwise it just becomes a pain and and from that perspective the university must decide on the learning management system and stick to it, irrespective of its problems, because I'm absolutely fed up with starting with Sakai, we had Moodle, then you know, now it's a Canvas. We better stick to canvas, otherwise they're going to irritate the hell out of all of us.”

Informant8 07:25 “Uh, so form builder their company based in Romania think and they, but it's an online platform. They have a an online support system. You know the chat with an actual person who could sort of type out your problems, and they've been incredibly. I mean all these years. I know I've I used that chat function a lot when I as I go through the forms and I I'm struggling with a certain problem and so on. Then they're able to resolve that quite quickly, showing me how to do it or fixing it themselves, or very often what they do is they just create a little video. It's a silent movie kind of thing and then email it and then you immediately know what the steps are so they're they're backup. Technical service is great, I think, yeah.”

Informant8 22:55 “And so I went on to it and I … tried to create a form and played around with it and I really struggled. I just didn't. Maybe, you know, you become very comfortable in what you're using. But I'm willing to try, and I'm willing to… be challenged, but it was so clunky and I don't know. It just … seemed too many steps to get to do to do what I wanted, that I found it. I gave up Limesurvey, even though the biggest attraction was that it was free, you know, and but it's still. I was prepared to pay for something that was a lot easier to use than to waste a lot of time. So that was my one example, of Limesurvey, and maybe it was if somebody just taught me how I would have had a different experience than trying to teach myself”

Informant8 25:01 “there's there's usually someone on the other end of the chat that will quickly respond, and I like the fact that it's another human being rather than, you know, just emailing it and waiting and getting a bot or something like that. It’s not a bot, I think that's the worst thing is a bot. Yeah, so you know they they get into your problems. They can solve it. They they they can get into the back end of your form and they say oh, this is how you do it and and and you learn that way.

So I think that backup service for me is like critical. You know that's a big thing apart from the intuitive and simple operational or ease of use, right?”

Informant9 18:00 What do I put all of those things on? Still today is Excel because Excel works for me and it. Yeah, but if I were a little more deft with data, don't you know with REDCap I'd probably put it into REDCap and give me all the answers that I'm looking for, but I haven't gone that route this year. But no, but I mean it'll come in to be absolutely frank. I mean, if I set my my finances up on REDCap, I would be able to get reports out of it. That's a lot easier than I get now, but like you know 'cause I've worked excel for so long. Yeah. Yeah, I like it. Gives me what I'm looking for.

Informant9 26:19 It's a two edged question to some degree and and and clearly the less support you need. Then the more intuitive something is the the more likely it is going to be adopted. Because I mean generally if you need support. It's going to be. Yeah, invariably at the time when you can't get it and then it either gets shelved or in one walks away in disgust.

Informant10 04:54 And yeah, I think I think probably the biggest thing is just it's there. You know, that's that's what's familiar and what's common, and what people have always used it was there when I came into the post. Excel Wizards and they can do magic with this thing, but I can't profess to be one of those. I just, you know, I think I've got a. I've got a fairly good grasp of it, but it's it's very generic, so yeah.

Informant10 18:58 A lot of the student groups, yes do use REDCap or their projects. I think. I think they're very often tend to be guided by their supervisors by what the supervisors are familiar with. And you know what they use or have used in the past. Many of them use red cap and also many of them at. You know, as you know, a lot of them do projects that are on diets are bases that are already on Redcap. So then you know then they exit access that. And some of them have used things like SurveyMonkey or Lime survey. And, you know other Google forms. Even Google based survey tools.”

Informant10 29:54 And I also think … we were forced into it a bit just because you know, those are the times we're living in, that you know, and the students coming up under us or so savvy and they know all of these things and we’re kind of pushed into adopting some of these methods as well, you know.

Informant10 30:50 Uh, I think I think you need to offer training. UM, the organization needs to offer training and support and there needs to be an avenue where when people are frustrated and they're just, you know, can’t figure out how to get it done, that they they, there's someone that they can go to who will say,

don't worry, I'll hold your hand through this process and you know, we'll we'll figure it out together because I do think that that that's a big part of it. People people don't like change, they're afraid of change they're, you know. They're very reticent to try something new, so if there's someone there who will hold your hand through the process and show you that it's not as bad or as difficult as you think it is I think that is a big help".

Informant10 31:33 "but I do also think that there's a time element to it, you know, because as I say, what what we found is that people are really reluctant because they think it's an additional it's it's yet another thing on their list of tasks to do that they've got a complete and they just don't have the time to do it. You know. So if they uhm. You know, like along with offering this training and support, there's got to be some way of of, I don't know, I guess a little bit …of offering time off, protected time, for people to be able to adopt those processes until it becomes integral to your workflow and it's you know it's just part of what you do and then then it's easy, then you know it's just part of your day, but but I think that would. I don't know how you would manage that. I don't know how you do that, but I think that that would be. Yeah, that would be a help

Informant10 32:34 What else? What else could organizations do you? I I do think there there's got to be a lot of marketing. I guess you've got a market certain you've gotta really. You've got to really show that your institution, and your organization has bought into this. And maybe I don't know, maybe incentivizing it in some way. You know, saying like if you use it, or if you meet these targets for this, you know we'll give you. I don't know well buy you lunch"

Informant11 34:36 "You know, I feel … there is this anxiety associated with digital and it has nothing to do with literacy or competence, right? I just feel like you know there are, there's a large group of people who are intimidated by this by this technology and and really, we need to bring everyone to a space where they comfortable, you know. And I think having heat drives some of these heats where one whole week, you know we have all these devices in the canteen and everyone can come at any time and there's someone in front of a device they'll tell you what it can do it. They'll tell you how it can help you. You know like I think people just need to start engaging with technology"

Informant12 27:38 "So I developed the first student evaluation on REDCap because I already had familiarity with REDCap and had already experienced the benefits, and then I tried to persuade our program administrator to set up the future REDCap evaluations. And yeah, he was very resistant to start off with, and didn't want to do it. And then you know, I said, you know, attend training. Here's the introductory session. Let me show you at the basics so that you can get started. You can use basically my, the questioning I had already developed and

just modify it. You don't even need to design it from scratch, and UM. And it took quite a while before he actually was able to do it. So, so it was definitely a case of of, you know, sort of like really reluctantly doing it. Now he enthusiastically does it, I will say. And and, and he's quick to to do it. And then he sends us the data set, you know, sort of. At the end, you know when when it. Once he's he's satisfied that we are not going to get any more responses then he packages it up in the emails it to the coordinator and we get it literally, you know, sort of within a few weeks of the modules. So which whereas before, I mean there were some times times we like, you know, six months later we still didn't have the captured spreadsheet of the evaluation, so."

Informant12 30:01 "Was was my first proper experience doing a REDCap questionnaire. So I'm I. I had. I was aware of REDCap and I had looked played around with it a little bit before then, but. And that was quite interesting, but I was already convinced about using electronic data capture. So for me at that stage it was really more about, you know, sort of what is REDCap going to offer and how user friendly is it etc. And and honestly, (PERSON NAME) and I sat and watched the tutorial videos and did it, I mean, after having you know, sort of like the initial discussion with you so. So that was actually, that convinced me and and and then since then I mean I've got so many projects and I've encouraged students who I supervised to use REDCap as well"

Informant12 31:08 "But now everybody does REDCap and you know, sort of within the our student body and they we actually teach them REDCap now as well as as part of their coursework. So they learn it in a couple of different ways, but if they're doing quantitative health measurement they actually do REDCap as one of the courses and once of the sections within a course I should And they they have to develop a questionnaire on Redcap for an assessment so and so I think we're really trying to to promote, you know, sort of the use of electronic data capture as as a way to ensure better quality data collection and and the fact that it can be, you know, interview administered or it can be self administered I think makes it really usable across any study, regardless of whether it's community based or whether it's like with health care providers or you know whoever it's with."

Informant12 32:31 "And it's been quite interesting because I've been working with a young researcher on that project, and he was more of a qualitative researcher, but he's come in and he actually I showed him some basics in REDCap. And then he he did do the course, so I actually learned some things from him, which is great and and and so so we and he's now now does our regular data quality checks and things like that. So on a daily basis or a weekly basis, he's checking REDCap"

Informant12 42:05 "So that is another important factor in this is who we collaborate with and what they use and that is definitely an influencer in terms of what an

electronic data capture system actually ultimately gets used, because it's usually a negotiated discussion”

Informant12 47:13 “I think the thing is about people seeing the benefit or hearing about the benefit and and I don’t know, you know, for example, whether it’s about uhm, you know, when people present their research, just being more mindful about saying, you know, sort of like we collected the data through, you know, sort of like using the the REDcap mobile app and you know whatever you know. Something which actually, I mean of course it goes into published papers and and we followed the protocol in terms of our referencing REDCap in the published paper. But I don't know that we always do it in presentations and presentations are probably where we have a greater audience, at least within the university.”

Informant12 47:57 “So for example, we just had our research day last week, and uhm, you know, I wonder whether whether people actually even mentioned it, but I certainly think there is this idea of, you know, there are early adopters, people who you know kind of get excited by something which which they read about or hear about or whatever, and then take it on board quite quickly. And then there are others who need a bit more convincing. And I really think that only way that that somebody can be convinced is is really to actually appreciate the benefit. So, so you've got to almost have the experience of or somebody who you trust. And and who you respect, having had the experience and saying you know, wow, this really made a difference and and I think that people would adopt it more.”

Informant12 49:30 Even so I think if people understood the benefits that they would, that they would be adopters. So so it's just. It's just recognizing that. Probably we've reached saturation in terms of the people who really going to easily just adopt it. And and to some extent to reach the next group is going to take a bit more concerted planning and effort in terms of of how it is. Promoted, you know, discussed, uhm kind of engaged with across the university and and I actually think it's got benefits. I know that it's a very like Health Sciences kind of thing right now, but actually it could be university wide, you know. In a sense, it's a resource that's available for the university”

Informant12 51:15: “ But you know, it's it's the space evolves so much. If I just think of my own awareness of of like what is possible and how. I was limited by what I thought was possible versus what actually is possible.”

Informant14 25:57: “they seem to be using a lot of REDCap and they seem to be happy with it, Vanderbilt has a good relationship with this. Uh, so I tend to just support that just simply because…And then (PERSON NAME) always told me that they're nice people to work with, which always helps”

E.9 Theme: Systems that add value and a sense of control/ empowerment increase motivation

Domain: Enablers	
Theme: Systems that add value and a sense of control/ empowerment increase motivation	
Codes:	
Configurability	Systems that are highly configurable results in tools that are adapted to match processes more closely, as well as giving users a sense of control and engagement
Instrument re-use	Systems that are generalisable/configurable will probably be used over and over for new/emerging needs, resulting in an increased return on effort invested while learning/adopting
Data access and re-use	Systems that give its users access to aggregate data and reporting tools result in more motivated users as well as unlocking the value of the data through re-use.

Informant1 06:42 “And I. I mean, it may be creature of habit. Think that's why many people don't change from from what they used to, but but I feel like with Excel. The more you get to know it, yeah, the you know, the more you just see the capabilities that it has. Like you say. I mean for this particular project that I spoke about, that was my first encounter with pivot tables. And yeah, it's just. Yeah, it is really like magic so so yeah, I'm a big fan of Excel, but of course that's not appropriate when you when you when typing patient data for study on, you know on the floor in the in, the in the unit at the hospital”

Infromant1 10:14 “Our actual MMed databases is an access database and that specifically to track their research so you this. We also obviously fill in like a form per registrar and it would have their start dates of starting their surgical rotation. It has the protocol assessment date, the topic of the research, the supervisors, whether there's ethics, yes or no. Then you can take if data has been analyzed or write up as you know commands and then this space for notes which we always use. Once we've communicated with them, which is put it, you know in the note the date and say you know what the communication was about. So we find that quite useful. And it was basically started. It was initiated by the research quarter coordinated before me, so I just actually carried on with it. So that was basically the reason reason. What's the land? I do think Access for this purpose works better than Excel and then of course you can always export to excel. But yeah, so the so that's the other one that we that we use.”

Infromant1 17:24 “Look, I think initially with our (UNIT NAME) database they there was definitely issues and again it wasn't at the time it wasn't my call to stop using it and again I think REDCap is great to to log data there on a tablet in the unit you know rather than Uh, have this floating Excel document that nobody knows

whether whether latest version is. Why do you think it's great for that? But, for example, you would ask a patient Uh, are you a smoker? Yes or no? And then the answer would be no. But then there would be something under number of pack years. So I would I would I mean, and again I guess it's how you set up that that question there, but I would imagine if there's no all relevant questions to yes should not be available to a no answer."

Informant1 22:10 "I think it's obviously just the, the ease of use, and having it readily available and if I just think of, you know, some hospitals in private would have (an) electronic app where the doctor immediately gets the patients' results on his phone. So the data is immediately available to him to make a decision, at the bedside.

Informant1 22:38 So I think it's it's that having the information at the tip of your fingers rather than having you know paper files to find and sift through. I think the nice thing is is also you can you know you can search a electronic database to find specifics. Yeah, and I think again if if you. I think it would be easier to to. You know, get rid of the duplicate entries.

Informant1 23.26 So I mean, obviously also the fact that electronic data is the only way we can analyze data. It's the only way that we can import it into statistical software and and get, yeah, nice inferential statistics from it, so obviously that's is super important and.Yeah."

"Informant1 26:53 Because at the end of the day, if we are logging data for research purposes, so obviously I mean research is a major goal of this faculty. If we can, you know by means of a patient number or by means of patient identifiers, all log whatever we're doing. You know that it's accessible to everyone because the guy who's got you know pancreas cancer. Maybe the the new onset diabetes guy you know so that we can just all kind of start talking together."

Infromant1 29:25 You know the.The three out of of evidence based medicine where it's evidence based it's obviously patients entered an it's an. It's the experience and the decision making process of the Finnish and based on evidence based on unique patient data and personal personalized information on that picture."

Infromant2 22:58: They generally. Want to actually conduct their research and they will do whatever it takes to have access to data that is clean that it's credible so they would be more inclined to use the software and they'll be more inclined to understand its value in there for one to learn more about it and initially come up with suggestions and ways of improving it because they also understand the value and the benefits of using it."

Informant4 03:17 Yeah, well, I think what happens when you are a statistician is, you're the one analyzing the data, so everything that influence the quality of the data up to when you're ready to analyze it is very important. Anything from study design and how you collect your data that instruments you used to collect your data. Even the operational process of how you collect the data is is going to affect it so. I think that's how in the unit I got roped into more of a lot of data management from early study design or throughout the study, and even after the study is completed.

Informant4 04:12 Yeah, I guess because. You know…that in the long run, how the data is going to be used so there's … a lot of little tweaks you can do at the design stage that will just make your life a lot easier and will just make things run a lot more efficiently

Informant4 15:00 “because our data manager, I think was more was. Just a more familiar with SQL and all of. Not functioning as care, we just did everything. Uh, in SQL and then he kind of got pulled to another. A huge project in our unit. So all of these other studies that would come up. We'd have to. People would have to fend for themselves, and the researchers would actually have to develop a database for their project and that kind of thing. And that's when I got more involved on data management. An I don't know SQL programming that well to develop a database in it. So right capital is just so easy to get started on. Even our junior data managers can help. Gonna go, researchers could help, so that's when we switched a lot of our some of our at the studies. And then even when we, we started partnering with different research units to help with our data management, and they also preferred REDCap so.”

Informant4 18:45 “Yeah, we have a. I think we have a team of data captures if that's what you're asking and they capture data so they have a paper-based case report form and they just capture that or they get the paper based hospital records and they just capture that on to that database. Interesting enough, we do we have so we have data capture and then we have a position in our unit called data administrator and they manage all the data captures and maybe just do a little bit more admin work. Kind of. Maybe might work with the researcher, be that in between between the data captures and the researcher and we've actually been successful in training them on red cap and find that they are able to create a small database in REDCap. And yeah, and learn a little bit about. But it's just when I guess one of the one of the great things about Red Cap is that anyone, anyone can use it. Anyone can learn it. Anyone can use it so. People that have in our unit that have. That have been promoted to these data administrative, they have been able to learn it. Just they are. Just by our ad hoc training, I guess, yeah. YouTube videos and that kind of thing.”

Informant4 29:27 “especially if a unit, has been using ….has one system of doing things. That they kind of just adopt for every project. Changing that whole system is very scary. Uh, nobody wants to change just for fear of things that could go wrong. I guess change in any circumstances scary, so that would be, I think just a hesitancy to change.”

Informant4 33:43 “Yeah, oh, and then I would say another thing that we come across a lot and I don't know if other units also have this problem but. We typically start a study and it has one objective for a year, and then we find funding to continue it and maybe slightly altered things. So we're constantly changing and updating. How we collect data for maybe a certain a certain study? Ah, specifically with our observational studies. That we had, yeah.
No, exactly, so we've had to restructure and then, well, we end up doing is, you know, just maybe starting a fresh or something. Uh, and then combining all that information is quite difficult. So it would be nice to. Yeah, I don't know how you would do it, but have some functionality where you can just restructure everything at once. Uhm? And and then carry on, yeah, but not have things you know here from the first two years of your study. And then there in the next few years. And then then the next wave.”

Informant5 12:00 I don't know what benefits it seems to have certain benefits over and above SPSS. I don't know how easy it would be given that I'm not quite familiar with SPSS yet. Well, not to the degree that I would wish to. So perhaps maybe learning Tableau are at this point is too ambitious. Perhaps one should just really learn how to use SPSS before trying to move or graduate to to those others you know.

Informant6 30:30 “. And it wasn't really. It was just a very simple thing that I could pick up and. You know, so I don't know. I suppose it's a learning curve as well, and maybe we you know, as the more we engage with the system, the more confidence we get from it. And in terms of problem solving, you know as we go along”

Informant8 04:00 “I create a whole lot of these survey forms or data collection forms just because I've been using it for years and I'm very familiar with it and so I can navigate my way around it and I can draw reports etc and so that's the one I like it because it it allows me to. Maybe 'cause I'm just familiar with it, right?”

Informant8 06:10: “Uhm, what attracts me most do it then and even now is the ease at which one can create the form. So it's a very. So be user friendly system that's been designed where … I can create a form within minutes you know, because they've got all these options of the the fields so to to to navigate around it.

And even if even though I've been using it for years about to show it to someone and say, you know you could do a form within within an hour, they'll be amazed at how many options they have and how, how simple it is to to to put those. Various fields in and, so that's …the biggest attraction for me”

Informant8 06:58 “The other part of it is the ease at which one can draw reports 'cause it allows you to go and have a look at a database very easily and also draw down an Excel or CSV file of the data. So that definitely makes it …very attractive.”

Informant8 23:42 “Uh, maybe I was like impatient, but I think that will be the deal breaker is that, is it gonna take a lot of time for you to learn something and not feel you know, you've wasted a lot of time, you know you, I think one is prepared to spend money just to save a lot of time. Because especially if you're going to keep going back to it, you want a system where you can keep going back to it and create another form and another form, I feel.”

Informant9 21:35 I think that one of the you know so so one of the things that really has has made, I think. I'm saying it's not easy as is being able to have something that is. Sufficiently adaptable. Good for people to use it, and I mean, I think that we've got beyond that around. REDCap. But and and the other that that I think is always being quite interesting, is this issue in terms of interoperability? You know, so you know.

Informant11 10:19 “And with graphpad and that allows us to plot the data and you can change the little colors more easily. You can get a wider range of display options so that you can make your dates. I look nice so that it goes into papers”

Informant11 35:15” Then the third is I feel like we’re only tapping into maybe 1 to 2% of the potential of our data, because once you have this data the way you data mine and you use big data because very soon if we all adopt this, this this electronic approach, very soon we'll have a lot of big data. It won't be in filing cabinets, it will now be big data and I think how, how you ask questions of that data and how you interrogate it. I I think actually having formal courses and formal programs. Not everyone is interested in it, so I'm not saying we should do it for everyone. But I like, I know there's a discussion about a data science institute or something like that, but I think developing more data driven initiatives, the university can think about how to resource those.”

Informant12 15:15 “No like it actually, I feel like I have much more control over it. I can't even tell you, we’re on version 17 of our (PROJECT NAME) questionnaire, and we've had so many problems. And the problem is that I can't go in and fix it. So we relying on on somebody who we've outsourced to, and that's that's my frustration, because all my my REDCap projects I control, so so I can make

changes I can, you know, sort of like test it. I can do all of those sorts of things and check the logics at, you know, the the the skip patterns and all of that."

Informant12 35:00 "And then the other piece about electronic data capture systems that I do realize is that. You know, if you use them all the time, they really easy to use and if you use them, which is often the case with with research is you're doing a big development in a big build up front and then maybe you're not developing another one for a year or for two years or something like that. And you forget..

Informant13 17:01 "So which year? Which obviously I solve the problem with the service solution. It's also not easy to. It's easy to create the forms to go and collect the data, but will be away with data is saved in the database. Also requires a good skills to get the data out."

Infromant13 18:51 Uh, we have the people with the skills. It's just expensive as yeah yeah as you know, getting data, people, data people are very expensive. Yeah, yeah, it's very expensive to get. There are people and the UM? Uhm yeah, it's a little bit complicated because also offer many of the nature of the data. Unfortunately, there are no easier way, UM, yeah, because you cannot be run with surveillance as a cross sectional studies you need, uh? To update the information on the existing information.So you always need to keep track of who's in the population and what happened to them, and that's what complicates it, and that's what complicates even with systems that we use. And also with people that you need, they need to have good data management skills in order to work on this kind of data."

E.10 Theme: Skills and human resource development maximize efficacy and let users feel empowered

Domain: Enablers	
Theme: Skills and human resource development maximize efficacy and let users feel empowered	
Codes:	
Training resources	On-demand resources like tutorial videos and documentation sites allow users to resolve issues on their own, increase their skills and lead to a greater sense of control and empowerment. Facilitated/schedule formal training can help reduce fear through interacting with an expert, but is less useful if it doesn't coincide with actual adoption.
Dedicated data roles	Having posts dedicated to capture, quality management or analysis of electronic data provide quality and efficacy gains for research projects and operational processes, while also reducing the burden on nurses and clinicians.
Formal capacitation requirement	Individuals often feel that they do not have time to learn new skills. By making skills development a formal deliverable in employees contractual obligations, both motivation and protected time is provided to engage with training resources

Informant1 9:46 So I mean, just thinking further than just data capturing. We also are putting together, we've actually put it together, a motivation to the Dean to set up like a Research Institute at the various hospitals. Well we specifically obviously had Bara initially, 'cause that's where we have such a great patient cohort. But yeah, to have everything together like a research nurse, so we on top of all the clinical and demographic data, data capture, making sure all is there, a technician to immediately analyze - processed samples, not analyze, process samples. So yeah, just a team working together, but I I think even if we can have a designated data capturer or two for, just you know, Uh, for for departments that are doing a lot of studies. So to have that person at Bara, and to have that person at Charlotte, so we know the data is being captured and if anything is missing, this person is going to follow up. So only other thing obviously is these hospitals need electronic patient records. That would also solve a lot of problems in capturing data you know, rather than going through all the files with missing, you know sheets of blood results and it's just yeah"

Informant1 13:45 "For example, I have a I have a master students that's also using REDCap. Then when he exports his data or we explore this data. You know it's literally zeros and ones for whatever you know, male or female or whatever, and what. Maybe again this is maybe us not knowing how to do that, but. So this students in particular was short for time to analyze get his data analyzed for his afternoon presentation in the department. So basically I had no idea what zero

was and I had no idea what one was for. So many options and he could not get away of also exporting the coding. Yeah, so again. It's because we all now just, you know, using it to using that REDCap too too too. You know, especially if it's registrars tapping in on on bigger studies so they would export the information that's relevant to their study, so not being necessarily a person who's ever used red cap."

Infromant1 15:37 "Yeah yeah I must say like you would know when we started adding a redcap introduction to our research methodology course it's I think it's been maybe four years now. If I'm not mistaken or. Something like that, yeah? And I think it's it's obviously great to make people aware and and then at least they've heard about it because they do use it when they rotate through all our units. But you know, I think maybe maybe having I don't know a training session with with us, you know, on the floor once you're something just showing. This is how you extract that. This is how you deal with information like that. Maybe, maybe actually a way of overcoming that barrier of actually I don't know and I don't have time to go and look and Thank you back and if we can say listen REDCap is yeah Wednesday afternoon for an hour showing you exactly what to do to get your data out of REDCap like I think that would be very useful."

Informant1 26:53 Again, I think we'd need designated people. And those people should have access to. I'll give you an example like when I worked in the UK. If you like, I mean I was somebody who was analyzing patients blood for research purposes, but also for treatment purposes to determine treatments. So because of that role I had access to the electronic patients records and I could go in and I could enter my results. But at the same time that you know that that access that X is too. Maybe all to you know, not not edited entire record, because obviously that that has a lot of risk. But you know. So basically, when anybody else in any other departments uses that same patients, everything is available today. Because at the end of the day, if we are logging data for research purposes, so obviously I mean research is a major goal of this faculty. If we can, you know by means of a patient number or by means of patient identifiers, all log whatever we're doing. You know that it's accessible to everyone because the guy who's got you know pancreas cancer. Maybe the the new onset diabetes guy you know so that we can just all kind of start talking together."

Informant1 30:22 Yeah, you know I I think uh, the simpler the better obviously. It's great when it has so many bells and whistles. Anything is great with many bells and whistles, but yeah, to get your head around how to, you know use those bells and whistles, that's I think and and yeah again, I think if. If it's maybe, like I said, those those targeted like info sessions or just you know how to like, we've changed our research course to have a lot of how to things were things that people keep asking us like how do you use your automated referencing system and we just

have a practical. This is how you do it like it's 15 minutes quick and easy, but it's a how to session, so maybe some how to sessions, maybe even just webinars or. Things like that that would be that would be great. Actually, where you can look at it in your own time and you don't have to, you know, go and attend a three day course or. That's what's great, for example, I use STATA for statistical analysis. And I tell you there's nothing that you cannot get a YouTube video on to explain what to do in STATA for a particular test, it's amazing. They have a designated YouTube channel for their, you know their training. Yeah, and I think that would be nice, maybe even just in your REDCap, you know, have a REDCap website for Wits and have short little tuts. If I'm ja, REDCap specifically, you know we all are acquainted with Excel, and I think that's also for ease. You know your supervisor knows how to look at your Excel document.

Infromant2 16:33 (asked if training resources are important) “Absolutely yeah. So just to give people that confidence, you could either make them a face to face …. And also remotely if people say oh I don't have time, then it they convenience they can just look a little bit step by step instruction, even zooming in on the actual software showing that the service would be dummy proof such that no one complaints at today's user friendly, it's available.”

Informant2 17:06: “Absolutely, there has to be for me. I feel there has to be someone for each and every single department who will check the quality of the data”

Informant2 19:03 I think I'm kind of like sitting on the fence with this one because what you're saying is there will be a possibly because we dealing with medical data. It'll have to be somebody in the medical profession. Other question is, are we talking a nurse? And then there's may not know all the medical terminology and secondly they may not even be able to read the handwriting if the data was actually initially written. If the doctor captures the data themselves, then it's easier in terms of quality control 'cause they know exactly what they did and they can be right. We know what they think is necessary in the report. Whereas if it's a different person, it'll help in a sense that there will always be somebody you know reliable. Sitting down, making sure that the data is captured, but on the other hand, what about the quality of the data, the integrity of the data, so also in terms of like medicolegal record, legal issues, I could argue as adults and say no, this is what I actually wrote with this what I say. Signing it off so he could work. So there has to be like a very like solid protocol as to who does what and other circumstances.

Informant 2 21:39 “I think for clinical workflow because the instances were like, you, as a doctor, you under a lot of pressure and you need to find the answers almost immediately and the person, perhaps that is usually in charge of the system, is not around and it's an emergency. You’ll want to be. It'll capable and

able, you know, just doing the basics and retrieving the information. Honestly, for myself, I believe in empowering people, and just giving them the resources because now you're thinking of one computer, one person or are we now saying there's a team of people like six people that you can go to, so those are some of the things that like obviously iron out. If it's one person, definitely not. Because when we talk about a department, there are registrars, there are MOs, consultants, fellows and then you know, so it's a. It's a it's a large team of people and you cannot now have only one person to be the go to person or even two. So it means that we need to have a team and also where do you then keep them because they need to be accessible. Will you keep them in the wards or will you create, I don't know like an office for them remotely and the doctors are expected to call them so those are all the things that you also need to look at before implementing."

Informant3 12:57 No, we don't. What we normally do is if there is a transcription process, we do have either dual encoding so geocoding show so. Otherwise, every there's somebody checks the the transcriptions instead of dual input. Have somebody, let's say, take 10% of the data that's been imported and check it. Uh, so no, we don't have dedicated individuals for transcription of data from paper to electronic or anything like that.

Informant3 21:25 :F or my own. Experience there's push and pull factors. The the push is normally when your current. Situation, your current way of capturing and storing data is no longer meeting your needs. Uh, so you get pushed onto a new system, which is more capable. So for example, moving from Excel, it's not no longer serving your needs, so you move onto REDCap. The pull is. If you can sell it to the person that very early on so you get them to adopted before they become entrenched in the old, let's say using Excel, so selling them the the virtues, the benefits of using something like red cap. So there's the forced migration and there's the. He enticement mechanism I suppose for getting people to use it. And I know the faculty runs lots of redcap workshops. Uh, but workshops build familiarity with a tool with people that already want to use the tool. Uh, I'm not sure if it's a way of enticing people onto the tool using the tool, and I'm not quite sure how to do that.

Informant3 22:43: "Uh, I don't know if we have to start very early at the post grad level. Not even the post grad level. Let's say the honors level. Uh, almost making it mandatory that on the students when they collect it, or in Med students when they're capturing data user redcap (questionnaires) Partenaires supervisors who don't other users like me and requiring people to go out and learn it themselves so it's I don't know it's a difficult one. How to entice people to use a new technology.."

Informant4 03:17 Yeah, well, I think what happens when you are a statistician is, you're the one analyzing the data, so everything that influence how the quality of

the data up to when you're ready to analyze it is very important. Anything from study design and how you collect your data that instruments you used to collect your data. Even the operational process of how you collect the data is is going to affect it so. I think that's how in the unit I got roped into more of a lot of data management from early study design or throughout the study, and even after the study is completed.

Informant4 04:12 Yeah, I guess because. You know, you know in in that in the long run, how the data is going to be used so there's little. There's a lot of little tweaks you can do at the design stage that will just make your life a lot easier and will just make things run a lot more efficiently.

Informant4 18:45 “Yeah, we have a. I think we have a team of data captures if that's what you're asking and they capture data so they have a paper-based case report form and they just capture that or they get the paper based hospital records and they just capture that on to that database. Interesting enough, we do we have so we have data capture and then we have a position in our unit called data administrator and they manage all the data captures and maybe just do a little bit more admin work. Kind of. Maybe might work with the researcher, be that in between between the data captures and the researcher and we've actually been successful in training them on red cap and find that they are able to create a small database in REDCap. And yeah, and learn a little bit about. But it's just when I guess one of the one of the great things about Red Cap is that anyone, anyone can use it. Anyone can learn it. Anyone can use it so. People that have in our unit that have. That have been promoted to these data administrative, they have been able to learn it. Just they are. Just by our ad hoc training, I guess, yeah. YouTube videos and that kind of thing.”

Infromant4 32:00 “I think the universities really does well on giving staff. And students introduced to REDCap and getting them up and running with. Kind of your basic redcap skills, and even maybe slightly intermediate. I think there's still a lot of. Advanced capabilities that we're not tapping into, so maybe having. Uh, a little bit more focus on training staff too. To use that or more, I think once it gets to that, once it gets to that level, it's kind of on a project by project basis, you'll find that one plan. Ensure you see a lot of it where one project needs this specific functionality and another needs that. So yeah, that would be cool to have. Uh, I guess kind of these consultations.”

Informant5 08:00 I'm not there yet in terms of managing that data very well, but I'm only getting to learn how to. You know how to process the data, how to quick it up, how to analyze, and the different tools to use, like your, SPSS, and. And I was trying to think of other ways to to manage my qualitative analysis and I'll try to look into en, vivo and. But I I realized that perhaps that's too too advanced for me at

this level. Maybe at a later time. But that's that's basically where I am. I'm still taking baby steps

Informant5 41:08. But there's only one one area where I feel. Yeah. I would be better served than just moving to to to at least he I, but I I think it's not a train smash. I think I could still do it either in in Excel or some other. But I'll see when the time comes, I think just the display, the visual. Yes, if if if I don't achieve what I wish to do by myself in Excel. Then I feel like could. Migrate, but I've already worked up into Atlas TI I and and see if then the visual make up that the effects from from using it would be any better.

Informant5 47:53 Look I I do think this is doing very well in offering workshops and. For for some of the the tools that it makes available to its staff. So that that I think to me would be the starting point and I think. Other than those, it would be good if they could advertise. That they're going to be doing those workshops earlier on. You know if Eli on in the year there's like a schedule of when so so so and so workshops will be held. Then we can also plan our time around that because sometimes we interested in something in really so, but it's it's during a time that we are so bogged down with. But if we know ahead of time, we can also plan uh affairs in such a way that we we free that time off so we can also go for for training on such, you know. So I think that would be my first knowing in advance what's available and when the possible workshops could be held

Informant5 53:41 but you also mentioned something that I thought was quite.To me, I think that's a major. And. factor you mentioned something about? About having people to assist one on one, even aside from the workshops, perhaps a mentor of some kind. And I think that would help, because for some people like myself. Who originate or come from the natural sciences background, but you are finding more and more that they have this interest in. More qualitative or quantitative. Type of analysis. Look, most of the studies we can only contact at this stage is for small small that the numbers aren't that big and sometimes with a smaller numbers. It also limits you as to the type of. Tool you could look towards using and while one may may be interested in expanding to those tools that analyze bigger. Amount of data we don't have access to that data, so if there could be that type of partnership, mentorship type of per program or facilitation so that for those who would be interested, they could then be partnered with and the partnership could be done in such a way that it's with someone you feel comfortable with.

Informant5 56:47 Sometimes I feel I want, you know, you can learn. You can go onto YouTube. And learn how to use some of these. But if you don't have data coming in that you can play around with and work on and do analysis on and beyond doing the analysis, then communicating with someone to to really

understand what the results you've gotten mean. And having that exercise of trying to put together a summative? I agreement of what the data tells you, the results that you've gotten from there, and having someone look through it and tell you your shortcomings and what you should do to better your understanding. Then it becomes futile because you've tried to learn. You've tried to do this, but you really don't know. You're like idea in in here like you don't know if you're doing things right or not and what the meaning of this is and what you should have done. What you shouldn't have

Informant6 14:00 “But I also got a assistance for him. So you know, sometimes I would ask some of the post grads that that won't PMA just to input data for him just to play catch up around that.”

Informant6 30:25 “so like for example the language thing. With this I think it was HTML coding or something that you were using in there. Uh, so after our second meeting I had another problem. Uh, but I just Googled HTML coding or something around that and I was able to figure out the issue immediately. Yeah, so, but I didn't know it was that easy. Otherwise I was I didn't want to. I felt so bad about calling you. OK 'cause I knew you were busy so I thought let me just try and figure this thing out if I can in my own. So I suppose it's also having a bit of and that’s what I mean just having this drive to try and explore it. But there is hesitancy and I think that hesitancy, comes with a fear that it's more complex than what it really is. And it wasn't really. It was just a very simple thing that I could pick up and. You know, so I don't know. I suppose it's a learning curve as well, and maybe we you know, as the more we engage with the system, the more confidence we get from it. And in terms of problem solving, you know as we go along”

Informant6 39:00 “Uh, so I think that's something that you guys might want to look into. And also I have been more workshops and stuff like that so that we can, you know, really develop not only ourselves but students as well. So I find that. Uh, you know a lot of the time it would have to be. The supervisor goes and in this information is that disseminated down to the students, but I think if there's something specific for students and maybe I'm just not aware of it, maybe it's already there.”

Informant7 09:11: “I one thing I can tell you, I'm self taught or all my computer. I've never attended computer courses because at the time when they came. Uh, into being, you know, it was seen as this grandiose thing and they would only send certain people and the rest of us minions were never sent on courses. So I just sat and talked myself and so I I know I have gaps and holes in my knowledge of use off of certain, particularly things like itself. But you know, I I educate myself as a requirement.”

Informant7 17:41 “If I think how I started at Wits I hit the ground running. And somehow any capacitation has to be outside working hours or in in my own time and so on. And the tools. It's like sending me to the garden and saying make your own fork and spade while you dig with your hands. And I think that the university should have a very structured induction process for lecturers and and even the professional staff where they say you have to get this course done to competency. At least basic competency. If that had been done for me I think and the time is put aside, it's not somewhere in your lecturing from eight to five. Find the time to learn how to use X, which is what is happening even now as I sit as head of school. So so I think there is. Lot of. Uh. Taking fom granted. Uh. The the extra time that is required of academics and then they burn out and then they can hardly do anything anymore”

Informant7 28:35 “So I think it's again related to having a similar sort of outfits like (PERSON1) had but in the data space. So that basically 'cause I know there is the the statistics support but they need to link that with data. I'm so that one can say look up done so I would love to be given time to say I've done these studies. This is the data I have. How can I make sense and pull it together and spend some time doing that? And then I think that will actually increase the number of publications and because a lot of people stop and freeze at the data point, yeah?”

Informant8 12:40: “Uh, it was uh, so I like the training. It was very supportive and I I really felt I knew how to use it. Then I think my mistake, my error. It's my own error was not having both something immediately after that because you've got actually just do it. You can't sort of. Just remember this weeks months later, you've got actually get your hands dirty and play with it. And I had come for the training, but it wasn't as though I was about to build a database. So I mean, if I do advise someone, I would say, you know, do it just before you build a database. Or just build a dummy database just for the sake of it so that you make all the errors that become meaningful in your learning rather than just store that in. For me 'cause you forget to all the steps.”

Informant8 15:00 “The clinical data and the operational side where patients I admitted every day and we capturing that information like on Redcap, we depend on two things. One is we get sometimes volunteer. Don't call it volunteer, but there's sort of these learner ships, interns that come from the apartment of health or labor that come for a period of six months or a year for training that the department pays them a stipend and we use them to capture information, whether it's children or neonates, little babies, or other end.

Informant8 16:10 “If it's paid for research, it's done very well because there's dedicated people paid for that job. If it's not paid for, it's a variety of ways that data gets captured and it's not great. As you would imagine.”

Informant8 28:47 “the second I think is the lack of dedicated data capturers, which is obviously a big (one). Cause we’re relying on people to just fill it in like the doctors and nurses and so on. There isn't a great motivation, …to do this and so they won't do it very well. And half-heartedly and grudgingly. And so it doesn't become good data. You need data capturers to enter it and you also need data cleaning and so on”

Informant9 29:32 Yeah, look, I think that yeah. I mean, that's that's a logical take up that whole situation, but I think that the approach they should be slightly different if you. If you've got. I mean, if you've got people who have to then bring in, yeah. Simple makes it better and and you don't then yeah and and it goes around. Recognizing that what they're doing is is that they really are just becoming importers of data. Uh, you know the the problems that you and I will have. So either in the development of an instrument, which I wouldn't want them to be involved in, that all or in terms of extracting the data and analyzing. But what then just needs to be done. This is that they just have to have a very simple input. Yeah, if if necessary they need some upwards like that again is quite simple. You know one push of a button. Here are the blood results or this is the trend of the blood results and you can do that. And I mean that's really got everybody does that nowadays. Whether they do it on. Yeah but but the area that you and I are interested in, which is to to to make sure that there is. The multilayered structure to it. That I think needs to be done by. People are interested or by people who who who are. Kind of giving the support for that situation,

Informnat9 32:57 Yeah, so I think that we need to start thinking about how we going to apply big data. Into the health system and and I think we're going to get into. More and more complex diagnostics and and and treatment algorithms. They're not coming so so. How how would I want to? Put us into a suggestion that we in a position to do that natural for one is that we at least got some of the background data. But more importantly the skills. So and and and that for me is really the. The yeah. The long term issue. And I do think that I mean if one is going to start talking about it is is that I don't think we are. Making people sufficiently competent at these skills to to achieve. No, why would I be talking to you about that in this setting? Because I do think that we don't over it or we do not sufficiently emphasize the need for information. I don't think it is. And I'm I would hope that we would get people. To start thinking that that's the norm.

Informant10 31:33 “but I do also think that there's a time element to it, you know, because as I say, what we found is that people are really reluctant because they think it's an additional it's yet another thing on their list of tasks to do that they've got a complete and they just don't have the time to do it. You know. So if they … along with offering this training and support, there's got to be some way of ….

offering time off, protected time, for people to be able to adopt those processes until it becomes integral to your workflow and it's you know it's just part of what you do and then then it's easy, then you know it's just part of your day

Informant11 12:13 “So in the beginning I didn't in my data really suffered for it. Uh, so over the last five years we consistently make sure that if we start new studies, we budget appropriately for the data capture function, yeah? We have to do it, otherwise the data and then if if it's tricky because so so and I think we learn as we go along. So initially I thought yesterday to capture was fine and so we we had a salary for data capture and you really sometimes led by the amount of funding fund is provided to you. And then the data capture was entering the data, and there's a fair amount of. I mean this human error right in and so we kept going back saying look, there's some things you keep making the same mistakes on, and she said actually, you know the place where she came from. There are two layers of data capture, so if you want to capture any claimant kind of data unit to employ a minimum of two people, someone who enters the data and then someone who checks the data so so that doubles the budget. And in many cases from funders, the budgets quite restrictive so we don't do that at the moment. We don't hire two people. We had one person and then what we do is we have graduate students who who who do some department go to tease because they get bursaries and we ask them to check the data.”

Informant11 35:15” Then the third is I feel like we’re only tapping into maybe 1 to 2% of the potential of our data, because once you have this data the way you data mine and you use big data because very soon if we all adopt this, this this electronic approach, very soon we'll have a lot of big data. It won't be in filing cabinets, it will now be big data and I think how, how you ask questions of that data and how you interrogate it. I I think actually having formal courses and formal programs. Not everyone is interested in it, so I'm not saying we should do it for everyone. But I like, I know there's a discussion about a data science institute or something like that, but I think developing more data driven initiatives, the university can think about how to resource those.”

Informant11 36:02 “Uh, and then I think engaging so you know UJ has invited me to to to talk for a three week course that they're giving in January next year where they just taking all 30 engineering and computer science students and the inviting them to the scores. And it's all about. Here are the problems of the world. How do you use the you know what you've learned about four and five are? How do you? How are you going to solve problems they've asked me for three projects. I must just throw them out. The students are going to pick them. And then for three weeks. I'm gonna work with those students and solve problems so I do feel like. We're not engaging the undergraduates community sufficiently in this. We we not. We viewing them as students and we're moving ourselves as a degree awarding

institution, whereas that relationship can be so much more richer. But I think that those types of more creative approaches should be embraced”

Infromant12 19:12 “Well, I mean I I have had, you know. Obviously there's sort of like audio and visual pieces of being really important and and I must say, you know, sort of this. Could be, you know, sort of. The fact that I don't fully understand all the capacities, I must say I'm also self taught on on a lot of things so I'm self taught on red cap for example. So I haven't really ever. I mean, I've I've watched the videos, the tutorial's and those sorts of things. But I've never actually attended training, so so in some ways I do think that's self limiting because, you know, it's really through through going to an intermediate. Any more advanced training that you really learn all the capacities, but I do use some.”

Informant12 30:01 “Was was my first proper experience doing a REDCap questionnaire. So I'm I. I had. I was aware of REDCap and I had looked played around with it a little bit before then, but. And that was quite interesting, but I was already convinced about using electronic data capture. So for me at that stage it was really more about, you know, sort of what is REDCap going to offer and how user friendly is it etc. And and honestly, (PERSON NAME) and I sat and watched the tutorial videos and did it, I mean, after having you know, sort of like the initial discussion with you so. So that was actually, that convinced me and and and then since then I mean I've got so many projects and I've encouraged students who I supervised to use REDCap as well”

Informant12 31:08 “But now everybody does REDCap and you know, sort of within the our student body and they we actually teach them REDCap now as well as as part of their coursework. So they learn it in a couple of different ways, but if they’re doing (COURSE NAME) they actually do REDCap as one of the courses, or as one of the sections within a course I should (say). And they they have to develop a questionnaire on Redcap for an assessment so and so I think we're really trying to to promote, you know, sort of the use of electronic data capture as as a way to ensure better quality data collection. And and the fact that it can be, you know, interview administered or it can be self administered I think makes it really usable across any study, regardless of whether it's community based or whether it's like with health care providers or you know whoever it's with.”

Informant12 32:31 “And it's been quite interesting because I've been working with a young researcher on that project, and he was more of a qualitative researcher, but he's come in and he actually I showed him some basics in REDCap. And then he he did do the course, so I actually learned some things from him, which is great and and and so so we and he's now now does our regular data quality checks and things like that. So on a daily basis or a weekly basis, he's checking REDCap”

Informant12 35:00 “So I would try to build something and then I would assess, you know, sort of. Yes, the instructions, the whatever branding that I that I received you know was sufficient to to enable me to move ahead and to be able to do something. And then the other piece about electronic data capture systems that I do realize is that. You know, if you use them all the time, they really easy to use and if you use them, which is often the case with with research is you're doing a big development in a big build up front and then maybe you're not developing another one for a year or for two years or something like that. And you forget. I mean it was a bit of relearning even though I had done a build before in Redcap. Coming back for the (PROJECT NAME) project, I had to really remind myself about certain things and I I made a few mistakes. On the way we, you know, uh, Skip didn't work perfectly and I had to go and fix it and whatever. So so that would be my. My second thing is all my third thing where I am in my list. Uh, is is just around, you know, sort of like, you know, how easy is it to retain those skills over time? So are they? Are they skills that they require me to have to relearn or and or are they sort of pretty self explanatory that once I get into it I will recall and remember, you know, sort of like the the different steps.

Informant12 40:00 (asked if they budget for data capturers) Previously, yes, we would so. So that's been quite interesting, because that's obviously a saving. It's a massive saving, not too when we using electronic data capture is that we we come not capturing data off paper. But obviously if we are administrative, it's interview administered, then we still have the interview as opposed to Self administered. But where we do have a cost like for example we did include a budget.

Informant12 48:50 “But I do think that integrating it into training is is imperative. So what we're doing in our programs, you know, sort of where where students actually develop skills because at the end of the day, one assumes that if they, you know, they will be future researchers and academics and and you know, if they understand the benefit.”

Informant13 14:00 “This surveillance is an offline system, so we go collect the data and when we come back at the end of the day and being synced with server, it works so far. Ah, the only issue is that it requires a specialized programming skills. Unlike Redcap the Alps. Anyone with basic skills we can activate deform the object. Forms are easy to create. Uhm but with actual system that you are Chris warehouse of rosters are is a little bit complicated. So if we if, let's say, we lose one of our programmers, that would be a problem. Because when you we need to find somebody who's gonna lend their system and then we are maintaining. That's why we are planning now to transition to the service solution because it's also easy, easy to implement and also at the same time. Uh, we we are part of the SAPRIN network. I'm sure you've heard about the SAPRIN which is based on African. Uh, what population research infrastructure network and the other sites we

have already started are using our service solutions, so it'll it'll make it easier if there is a problem with always in Group that you can, you can refer to even if we we are in the worst case. Uh, we we lose one of the staff members. We can always. Learn from their other Sunday and and get back on."

Informant13 21:10 Yeah, before any study starts, we have uh, depends also on how complex this study is. Like for this surveillance we will train them for three or three weeks to a month. And also these other specialized studies we also train them maybe two weeks or three weeks or even a month, depending on your on your uhm, the procedures that are involved in these studies. Because some of these studies, they involve both administering the questionnaires but also are collecting blood samples. So and also we have to do like the consenting process is also electronic, so we have to go through all the different components of a of of this study with them and make sure that they are they have or mastered the study and we are all asking the questions, uh, in the same way, so that if we see differences in their responses, it's not. Uh, it's not because of differences in the in the way the interviewers have asked the questions because. Even though I'm, we translate the questions uh, into the local language. But I mean the same question somebody can ask it, uh, two people will ask it different and get differently by responses from the same or very similar individuals"

Informant13 32:23 "also uhm. It increased also the workload for the data management team, because when we should be able to process the data but there are lots of data in real time. Uhm, so we had you to add more people into the data management team and unlike in the past. Uh, so while we saved the costs in terms of the data enterer, but we also increased the cost in terms of data management personnel."

"Informant13 36:00 "Also, we need to hire people with the right skills. It's very important and the also be training is very important and normally what we do. So yesterday we needed twenty people to do A to do with food week. We don't. We don't train 20 people which then like maybe 50 people and we give him our assessments throughout their training period so that we can choose. We really were ones that are are the best. So it's very clear from the beginning we told him we have selected you and we're going to train you, and the ones that you pass be assessments from the training. Other ones that will make it and may be afraid of you. But we are only looking for 20. And that also helps. Uh, in terms of getting people that she. Well, well trained and well qualified to do to do the work. Yeah, we found that you are. If you just interview people, it's not enough"

Informant13 37:00 Yeah. The practical part. And Vinny, are you also need to have, uh, we? People with the right skills are as part of your, our data management

personnel. Uh, because there's lots of water.Data management data. Cleaning up reports that need to be generated in real time on daily basis. So I said look like."

Informant13 38:55 "Yeah, you also need a good IT personnel because once you start using the tablets when you have like, like in our case. Currently we have like maybe 250 members of staff that are going out every day into the field, so that's the 200 a day tablets that you are sending out. You need to find a place where you are gonna charge them overnight. Overnight uh, and also just making sure that you are tracking the equipment itself. You need good systems. Otherwise today you have 250 tablets. After a week you are left with 200"

Informant13 39:47 Yeah, so when we started … we used to have a lots of cases where our tablets would go missing, and then we tried hard to put in systems. Uh, to uh to reduce that, and I think the systems we implemented, because we work, uh we have like a dedicated team of only two people that are actually issue with tablets. So every tablet that is issued in the morning we sign it out and then you will be a few teams come back we need to sign it in and then if it was signed it in and then it goes missing then we only have two people to ask what happened. Uh, yeah, but occasionally we do have, like one goes missing. Uh, maybe are you here or there was a contractor that came and to work in the server room and the UM? Somehow they were left alone and when somebody takes advantage and then he takes your tablet but it, is ah, at a smaller scale at the moment, but it does happen"

Informant14 12:22 I think the starting point has to be that the doctors and nurses must never fill these forms out, but just test your starting point. If they're offering it in, it's not gonna work. That it has to be transcribed by somebody else and this is going to be the big sticking point, because then the next point is who's going to do the work. And you'll probably hear people say, well, no, the doctors nurses must do the work. Of course it's their job. And the thing about those. That's fine. You're not. You've now turned too much expensive human resource into incredibly expensive data transfer operator, and that's fine"

Informant14 45:42 "So one of the things I think you might want to really pivot away from this data collection role is data analytics. I think it's much more interesting and to be honest, I think that it's much less painful. Why, why couldn't beat nurses and doctors into making databases rather position yourselves to say hey, have you got existing data base and then scrutinize the database and say how clean is it? That's a real skill and following on that to say what's interesting from there."

APPENDIX F - PLAGIARISM (TURN-IT-IN) REPORT

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WITS UNIVERSITY

Dr. Ekene Emmanuel Nweke (PhD), *Pl*
Ass. Research Scientist and MMED Researc
Coordinator
Department of Surgery, Room 9M07

Tel: +27(0)11 717 2801
Email: Ekene.Nweke@wits.ac.za
Website: www.wits.ac.za