



Realising the benefits of digital health implementation in a middle-income country: Applying Theory of Change in Nigerian primary care

by

Taiwo Adegbaye Adedeji

April 2021

School of Computing

Supervisor: Dr Philip Scott

This thesis is submitted in partial fulfilment of the requirements for the award of the degree of Doctor of Philosophy of the University of Portsmouth

Abstract

Healthcare quality and evidence-based practice remain a grand challenge to be resolved. There remains a “60-30-10 challenge” where only 60% of care conforms to evidence-based guidelines, 30% is of low significance, and 10% is detrimental.

Digital health has been seen as a tool for the transformation of healthcare quality and safety globally. An electronic health record (EHR) system, a form of digital health, can be a solution to paper documentation bottlenecks in health service delivery if it is successfully implemented. This study aimed to establish how the benefits of digital health implementation could be realised in low- and middle-income countries, using the example of Nigerian primary care and the Theory of Change approach.

Theory of Change (ToC) is an outcomes-based approach that starts with the long-term goals and works backwards to the inputs and mediating components required to achieve those goals for complex programmes. ToC was developed to guide a pilot study and identify the preconditions needed to realise its long-term goal in Festac Primary Health Centre (PHC) Lagos, Nigeria. OpenMRS was used as the EHR platform, and forms and concept dictionaries were created to meet the needs of the clinical services. During the implementation study, interviews were conducted with the Festac PHC stakeholders. The interview transcripts were analysed thematically using the Framework method, and a system evaluation was done to test the EHR system’s usability. A workshop for health informatics experts was held. The study used qualitative document analysis to complement the interview and the workshop techniques for triangulation. The pilot study was evaluated using selected success factors related to specific categories.

The ToC approach identified real changes during the pilot study. The EHR adoption and usage data from the system go-live revealed that the number of registered patients and patient registration forms completed on the EHR system was 1790. ANC and immunisation encounter forms (n=198 and n=309) were completed. Vital signs (n=325) and visit notes (n=177) were entered into the EHR. The main technical components of OpenMRS are the database (data concepts mapping, backups, security, etc.) and the

EHR software (clinical modules and customisations). The interview data (n=14) showed that the EHR implementation was relevant and identified key themes relating to readiness, expectations and sustainability of the EHR implementation. There was a consensus by the six healthcare professionals (HCPs) who completed the EHR user survey that the system was not difficult to use. The workshop highlighted that data modelling, and interoperability standards are key priorities for maternal and child health data services in LMICs. Findings from the document analysis showed the relevance of the selected grey literature (n=15) in providing contextual information across the study. The study proposed a generic ToC map that LMIC implementers can use to introduce an optimised EHR with the assumptions about sustainability and other relevant factors. The critical success factors were the sustainability, financial and organisational categories. The PHC management and the research team agreed on solid arrangements to sustain the EHR implementation, but there was no guarantee.

This study has presented ToC as a rewarding approach in helping EHR implementers and health stakeholders to question their assumptions. It is apt in framing dialogue with stakeholders and serves as a framework for learning and reflection. Any future LMIC health IT implementation study in primary care can adapt this ToC approach to their contexts with necessary modifications based on inherent characteristics. Further work is needed to explore health data interoperability across public PHCs by designing a national health data model for maternal health services data set based on established data standards and examining the preconditions and drivers for implementing such a model.

Declaration

Whilst registered as a candidate for the above degree, I have not been registered for any other research award. The results and conclusions embodied in this thesis are the work of the named candidate and have not been submitted for any other academic award.

.....

Taiwo Adedeji

Table of Contents

Abstract.....	ii
Declaration	iv
Table of Contents.....	v
List of Figures	xiii
List of Tables	xv
Dissemination	xvii
Acknowledgements.....	xix
Chapter 1: Introduction	1
1.1 Background	1
1.2 Digital health	2
1.3 Digital health in LMICs.....	3
1.4 Nigeria overview	4
1.5 Healthcare system in Nigeria	4
1.5.1 Roles and responsibilities of the three tiers of government.....	5
1.5.2 Organisation of the health system.....	5
1.5.3 Healthcare facilities.....	7
1.5.4 Healthcare workforce.....	8
1.5.5 Rationale for the choice of Festac Primary Health Centre	9

1.6	Maternal and child health in Nigerian primary care	11
1.7	Digital health implementation in Nigeria	12
1.7.1	Current realities	12
1.7.2	Potential digital health architecture for Nigeria.....	12
1.7.3	Is the potential digital health architecture feasible?	14
1.7.4	Landscape of ICTs for health in Nigeria	14
1.8	Motivation.....	16
1.9	Significance of the research	17
1.10	Research aim and questions	18
1.11	Structure of the thesis	19
Chapter 2: Literature review		20
2.1	Overview	20
2.2	Protocol for systematic review	20
2.2.1	Background of review	20
2.2.2	Objective	21
2.2.3	Methods and analysis.....	21
2.2.4	Ethics and dissemination.....	26
2.2.5	Discussion	27
2.3	Results	27

2.3.1	Search results.....	27
2.3.2	Study characteristics	27
2.3.3	Critical analysis of studies	31
2.3.4	Logic model for included papers.....	33
2.3.5	Discussion	38
2.3.6	Limitations.....	39
2.4	Critical assessment of knowledge gaps and anticipated contribution.....	40
2.5	Chapter summary	41
Chapter 3: Theory of Change.....		42
3.1	Overview	42
3.2	Introduction to Theory of Change (ToC)	42
3.2.1	Origins of Theory of Change	42
3.2.2	Theory of Change: a process and a product.....	43
3.2.3	Theory of Change: a theory or an approach?.....	44
3.3	ToC and other evaluation frameworks	45
3.4	Chapter summary	46
Chapter 4: Primary research methodology and design.....		47
4.1	Overview	47
4.2	Philosophical perspective	47

4.2.1	Categories of philosophical paradigms.....	48
4.2.2	Philosophical perspective for this research.....	50
4.3	Research outline	50
4.3.1	Research design	50
4.3.2	Data description	50
4.3.3	Theory of Change approach	51
4.3.4	Success factors/criteria	55
4.4	Setting.....	56
4.4.1	Festac Primary Health Centre	56
4.4.2	Stakeholder meetings.....	57
4.5	Data collection and analysis	57
4.5.1	Interviews.....	57
4.5.2	The workshop process	58
4.5.3	Document analysis	59
4.5.4	Qualitative data analysis.....	60
4.6	EHR system selection and evaluation.....	60
4.6.1	OpenMRS.....	60
4.6.2	System evaluation.....	61
4.7	Ethical considerations	62

Chapter 5: Results	63
5.1 Overview	63
5.2 EHR implementation in Festac PHC	63
5.3 Initial Theory of Change	64
5.4 Revised Theory of Change	66
5.4.1 Revisions to the initial ToC	66
5.4.2 Long-term change	67
5.4.3 Assumptions	67
5.4.4 Wider benefits	69
5.4.5 Measurable effects.....	69
5.4.6 Outputs	70
5.4.7 Intervention	71
5.4.8 Stakeholders	71
5.5 Qualitative analysis	71
5.5.1 Description of participants	72
5.5.2 Theme 1 – Readiness assessment of the health centre to adopt EMR.....	74
5.5.3 Theme 2 – Expectations for the EMR and its impact on health service delivery95	
5.5.4 Theme 3 – Sustainability of the EMR implementation	106

5.5.5	Discussion of key findings	107
5.6	Technical implementation and system evaluation	110
5.6.1	OpenMRS demonstration	110
5.6.2	EHR application features and relevance to clinical workflow	110
5.6.3	EHR setup/configuration	112
5.6.4	System evaluation results	112
5.7	EHR interoperability	112
5.8	Workshop findings from the MedInfo 2019 Conference	114
5.8.1	Workshop overview	114
5.8.2	Group discussion	115
5.8.3	Drivers for implementing an interoperable EHR	118
5.8.4	Preconditions	118
5.8.5	Discussion and summary findings	118
5.9	Document analysis findings	119
5.10	Generic Theory of Change	123
5.11	Chapter summary	124
Chapter 6:	Discussion	126
6.1	Overview	126
6.2	Theory of Change for digital health implementation in LMICs	126

6.3	Critical evaluation against research questions.....	127
6.4	Pragmatic reflections on real-world experiences.....	131
6.4.1	Reflections based on experiences from other low- and middle-income countries	131
6.4.2	Reflections based on experiences from high-income countries.....	134
6.4.3	Reflections on data entry at Festac PHC	135
6.5	Limitations of the study	136
Chapter 7: Conclusions.....		137
7.1	Overview	137
7.2	Impact summary.....	138
7.3	Original contributions to knowledge	139
7.4	Conclusion	142
7.5	Further work	142
References.....		144
Appendices		157
Appendix 1 – Abbreviations.....		158
Appendix 2 – Search results		159
Appendix 3 – Logic model findings		163
Appendix 4 – Consent form		166

Appendix 5 – Interview guide	170
Appendix 6 – Favourable ethics opinion.....	172
Appendix 7 – Approval letter	174
Appendix 8 – System evaluation.....	175
Appendix 9 – Research Ethics Review Checklist	191

List of Figures

Figure 1: Levels of healthcare delivery and facilities in Nigeria	6
Figure 2: Number of public PHCs in Lagos LGAs	8
Figure 3: Map of Nigeria highlighting Lagos State (Adeniran, Otokiti, Otokiti, & Durojaye, 2020)	10
Figure 4: Metropolitan view of Lagos (Lawal, Abdul-Lateef, Ismaila, Yusuf, & Aina, 2020)	10
Figure 5: Building blocks for digital health architecture	13
Figure 6: Basic EHR functions	13
Figure 7: Sophisticated EHR functions	13
Figure 8: A simple logic model	21
Figure 9: PRISMA flowchart for the selection of studies	28
Figure 10: A typical Theory of Change diagram with components and descriptions	43
Figure 11: An initial version of the Theory of Change for the scheduled Electronic Health Records implementation in Festac PHC	65
Figure 12: A revised version of the Theory of Change for Electronic Health Records implementation in Festac PHC, including a workshop at MedInfo Conference 2019. .	67
Figure 13: Daily/Weekly data entry of registered patients to the EHR system	70
Figure 14: Electronic forms completed on the EHR system during encounters, %age of total entered	70
Figure 15: Atlas.ti 7 diagram notations	72

Figure 16: Overview of codes for EMR readiness assessment subthemes75

Figure 17: Mapping datasets from ANC and delivery applications using CIEL/OCL on OpenMRS116

Figure 18: A generic version of Theory of Change for Electronic Health Records implementation, without context-specific details 123

List of Tables

Table 1: Number of health facilities by the level of care and ownership across Nigeria .	7
Table 2: Number of health facilities by the level of care and ownership across Lagos State	8
Table 3: Infant and maternal mortality in Nigeria	11
Table 4: Summary of the PICOS elements included and excluded in the systematic review	22
Table 5: Search strategy for research questions (RQs)	24
Table 6: Study characteristics	29
Table 7: Summary findings from included paper	30
Table 8: Pathway A – Interventions findings.....	34
Table 9: Pathway B – Activities findings	35
Table 10: Pathway C – Outputs findings	36
Table 11: Pathway D – Outcomes findings	36
Table 12: Pathway E – Impact findings	38
Table 13: Overview of research design.....	52
Table 14: Theory of Change components and their definitions	54
Table 15: Categories for success criteria and their definitions for EHR implementation (adapted from (Deriel et al., 2018; Fritz et al., 2015))	56
Table 16: Assumptions and their sources	68

Table 17: Participant demographics.....	73
Table 18: Total number of analysed quotations from interview participants across themes.....	74
Table 19: EHR software modules/forms, data elements and relevant service points.....	111
Table 20: Abstraction layers for modelling data across MCH services.....	113
Table 21: Document analysis based on characteristics, themes, data analysed and location in the study	121
Table 22: Overview of the study questions and rationales	127
Table 23: Summary of successes, lessons learned from the pilot study in Festac PHC and implications for EHR implementations in Nigeria and other LMICs.....	129
Table 24: A comparison of EHR implementation findings from three low- and middle-income countries	132

Dissemination

Journal articles

Adedeji, T. A., Fraser, H. S., & Scott, P. J. (2021). Implementing electronic health records in primary care using the theory of change: A Nigerian case study. *Manuscript Submitted for Publication*.

Scott, P. J., Brown, A. W., **Adedeji, T.**, Wyatt, J. C., Georgiou, A., Eisenstein, E. L., & Friedman, C. P. (2019). A Review of Measurement Practice in Studies of Clinical Decision Support Systems 1998-2017. *Journal of the American Medical Informatics Association*, 0(0), 1-9. <https://doi.org/10.1093/jamia/oczo35>

Conferences

Adedeji, T., Scott, P., & Fraser, H. (2019). How can we deliver the vision of electronic medical records to improve maternal and child healthcare in low- and middle-income countries? [Workshop]. *MedInfo 2019*.

Adedeji, T., Scott, P., & Good, A. (2018). Investigating the benefits of open-source hospital information systems for low- and middle-income countries: A mixed methods approach [Abstract]. *Health Services Research UK*.

Acknowledged in the Front Matter for editing conference proceedings – Studies in Health Technology and Informatics (2020). *Medical Informatics Europe*.

Posters

Faculty of Technology Research Conference, Portsmouth, 2020.

Health Services Research UK, Nottingham, 2018.

Presentations

School of Computing Research Seminar, 2019.

Health Services Research UK, 2018.

Peer-reviewer

Journal of Medical Internet Research (JMIR)

BMJ Health and Care Informatics

European Conference on Information Systems (ECIS)

Acknowledgements

Firstly, I give all the glory to the triune God for the conception and the completion of this PhD! Without God – Father, Son and the Holy Spirit, I would have given up the PhD journey altogether. I am very grateful to the Almighty for everything!

Secondly, I appreciate my first supervisor, Dr Philip Scott, for his flawless emotional intelligence. With this intelligence, he supported me through this journey despite my funding challenges. He knew his onions and facilitated my research development with a unique touch. My resume is a testament to Philip's support for my career development over time. Also, I appreciate my second supervisor, Dr Alice Good, for her push and encouragement in helping me to see the impact of my PhD beyond academia. Many thanks to my examiners, Dr Bassey Ebenso and Professor Andy Thorpe, for their invaluable feedback.

Thirdly, I want to shout out to my helpers of destiny who have stood by me through the years. This list is in no way exhaustive, but I will attempt. Thank you to the Oluwabusolas, the Williams, the Adeekos, the Adus, the Oreyomis, the Adeyemos, the Bhadmus, the Awoniyis, the Agunbiades, the Yeomans, the Adegbolos, the Emere-Johnsons, the Ofosu-Ameyaws, Dean Chimezie, Foluwaso Owoyemi, Bunmi Atunwa, Moses Akintioye, Deborah Kabongo, Bolaji Iyiola, Vimbanashe Sibanda, Rebecca Kangau, Rita Ekhareafo, Obinwa Ozonze and my entire IFCS Family.

Fourthly, a special thanks to my family, who have stood by me through the thick and thin. My father and mother, Hon Sunday and Mrs Mutiat Adedeji, my twin sister, Mrs Kehinde Shopitan and my brother, Mr Opeyemi Adedeji. I appreciate my grandma, uncles, aunties, cousins and in-laws – the Lamidis, the Ahmeds, the Ojewumis, the Adedejis, the Kehindes, the Shopitans and the Bamgboyes.

Lastly, I appreciate my wife, Adefunke, for being a pillar of affection, strength and support. She is my *Corrector General* and number one fan. I am short of words, but you are my treasure, and I will not trade you for anybody or anything under God.

Chapter 1: Introduction

1.1 Background

Healthcare quality and evidence-based practice remain a grand challenge to be resolved. Since the evidence-based movement started in 1981 (Thoma & Eaves, 2015), there remains a “60-30-10 challenge” where 60% of care conforms to evidence-based guidelines, 30% is of low significance, and 10% is detrimental (Braithwaite, Glasziou, & Westbrook, 2020). There is a consensus that healthcare provision is faced with various challenges globally. These challenges include increasing healthcare costs, ageing populations, inefficiencies, inequalities and widespread diseases in developed and developing countries (Emmanuel, 2014; Karara, Verbeke, & Nyssen, 2015).

The Organisation for Economic Cooperation and Development (OECD) reports on the problems facing the health systems among member nations, mostly higher-income countries (HICs), ranging from the rising cost of healthcare to the need for equities and efficiencies as well as increase in the ageing populations (OECD, 2015). The World Health Organization reports that healthcare systems in low- and middle-income countries (LMICs) are also faced with problems of poverty, diseases such as HIV/AIDS, tuberculosis and malaria, out-of-pocket costs by patients, inequities and inefficiencies (Dye et al., 2013; Piette et al., 2012).

The UN’s Sustainable Development Goals (SDGs) have the global ambition of “leaving no one behind”. The relevant health stakeholders can improve the health of populations by identifying the current achievements and gaps for the health-related SDGs. Funding priorities are significant in strengthening health systems to fulfil the SDG ambition. For example, funding is made available to developing nations by development partners, donors, government agencies (e.g. GCRF, Bill & Melinda Gates Foundation, DFID, MSD for Mothers and MRC-NIHR) for international development projects such as health and wellbeing, environment and sustainability.

The novel coronavirus-induced disease (COVID-19) pandemic has vividly demonstrated the need for efficient and effective digital health systems. Accurate real-time data is vital for tracking infections, tracing contacts, monitoring viral mutations, and managing diagnosis and treatment (World Health Organization, 2020b). Developed countries have varied in the effectiveness of their pandemic responses, mainly due to policy choices but to some extent due to the constraints of their digital healthcare information systems. Developing countries mostly have a relatively limited digital capability in healthcare.

1.2 Digital health

Globally, digital health has been a tool of transformation for the delivery of healthcare services (Rumball-Smith, Ross, & Bates, 2019). Digital health was defined as *“the cultural transformation of how disruptive technologies that provide digital and objective data accessible to both caregivers and patients leads to an equal level doctor-patient relationship with shared decision-making and the democratisation of care”* (Meskó, Drobni, Bényei, Gergely, & Györffy, 2017, p. 1). Although this definition captured the change potential of digital health technologies, the effectiveness, sustainability and the context in which such technologies will be applied are to be examined. One of such digital health technologies is the electronic health record system.

An electronic health record (EHR) is defined as *“a repository of information regarding the health status of a subject of care, in computer processable form”* (Nguyen, Bellucci, & Nguyen, 2014). An EHR can solve the bottlenecks of paper documentation in health service delivery if it is successfully implemented, but poor implementation can waste resources (Waterson, 2014). There is a plethora of health records in paper formats resulting from the handling of clinical documentation across healthcare facilities in low- and middle-income countries (LMICs). Few electronic health records exist in LMIC public primary health centres (PHCs), the first entry point for citizens/patients seeking essential healthcare services (Adamu, Hamzah, & Rosli, 2020; Attah, 2017; Odekunle, Odekunle, & Shankar, 2017). It is necessary to manage the health records of these patients/citizens effectively and efficiently to ensure effective clinical workflow and

patient safety. Although paper-based health records seem to be structured and persistent in supporting care delivery, electronic health records prove to be more consistent, readily available and scalable for continuity of care (Evans, 2016).

1.3 Digital health in LMICs

The study of EHR systems implementation in LMICs is of particular interest to health stakeholders such as policymakers, funding agencies and care providers due to the efficiencies and evidence base resulting from the appropriate evaluation of such systems (Ebenso et al., 2018). Some progress has already been made in EHR implementation in LMICs, but sustainability and widespread adoption remain elusive (Oluoch & de Keizer, 2016; Reis et al., 2017). A few examples of such development in healthcare improvements include efficiency gains (such as quicker and more accurate reporting, reduced duplication of documentation and faster access to patients records), better patient tracking (such as immunisation records and clinic attendance), and mobile health applications (such as ubiquitous access to remote care for patients) (Meyers, Forsyth, & Velasquez, 2017). One example is iSante, Haiti's national electronic medical record (EMR) system. This EHR system was implemented in 100 sites across Haiti primarily to support the delivery of the national HIV programme (Deriel et al., 2018), antenatal care (ANC) and delivery, and primary care. In high-income countries (HICs), there has been widespread adoption of EHR, but this is not the case in many developing nations (Oluoch & de Keizer, 2016; Rumball-Smith et al., 2019). So far, only a few hospitals in Nigeria have implemented an EHR system of some form (Ebenso et al., 2018; Odekunle et al., 2017). However, there is a substantial usage of EHRs for disease-specific programmes such as TB and HIV (Amoroso, Akimana, Wise, & Fraser, 2010; Douglas et al., 2010; Fraser et al., 2013; Oluoch et al., 2016; Were et al., 2013).

Despite the proliferation of mobile phones, the Nigerian health sector has not leveraged the advances in mobile technology for maternal and child healthcare delivery, unlike some other LMICs (Lee et al., 2016). One example is Virtual Doctors, a UK-based charity that specialises in telemedicine and uses remote medical advice to local health workers to reduce unnecessary hospital referrals. Currently, the charity is working with primary

healthcare centres (PHCs) in Zambia and Malawi, where volunteer doctors, mostly from the UK, provide medical support through a mobile application. These provide medically qualified advice where the local community only has a community health worker, leading to faster diagnosis and treatment (Virtual Doctors, 2020). Similarly, the dominance of mobile apps in the financial and transportation sectors has not translated into the uptake of mobile health (mHealth) apps or telemedicine in the health sector (Eze, Gleasure, & Heavin, 2016).

This study uses the terms “electronic health records (EHR)” and “electronic medical records (EMR)” interchangeably. However, EHR is used predominantly except in the qualitative data analysis section (Section 4.5.2), where EMR is used more due to the contextual understanding of the concept in a pilot study conducted in a Nigerian primary healthcare centre.

1.4 Nigeria overview

The focus of this study has been Nigeria. This country is strategically positioned as the most populous country with the highest Gross Domestic Product (GDP) in Africa (Varrella, 2021). Moreover, the World Health Organization ranks Nigeria’s health system 187th out of 190 countries, making the Nigerian healthcare system one of the five worst healthcare systems in the entire world (Brown, 2018). Nigeria is faced with high healthcare costs and a global burden of disease influenced by HIV/AIDs, malaria, and other infectious diseases, resulting in a high mortality rate (Olaronke, Ishaya, Rhoda, & Janet, 2013).

1.5 Healthcare system in Nigeria

The healthcare system in Nigeria is multifaceted and mainly public sector driven with a substantial private sector involvement. The provision of healthcare services depends on the relevant legal framework, the nature of health care facilities, level of care responsibilities and the availability and distribution of resources across urban/rural settings.

1.5.1 Roles and responsibilities of the three tiers of government

Nigeria is a sovereign nation that operates a federal system with 36 states, 774 local governments and a Federal Capital Territory (FCT) located in Abuja. The country has three tiers of government, including the federal, state and local governments. Each tier has its roles and responsibilities concerning healthcare.

Public primary healthcare is the main responsibility of the local governments, with some resource allocation from the state and federal ministries of health through the state primary health care boards and the National Primary Health Care Development Agency (NPHCDA). The private sector also provides primary care services with fee payments.

The state governments are responsible for the regulation and management of the secondary level of care.

The federal government is responsible for the regulation and management of tertiary care. It regulates both the public and private tertiary healthcare facilities, but it only runs its public tertiary hospitals in all the federating States. The federal government is solely responsible for the funding of its teaching and specialist hospitals and medical centres.

1.5.2 Organisation of the health system

Nigeria's National Health Act 2014 provides a framework for the regulation and organisation of the health system, the relationship between various health stakeholders and sets standards for healthcare service delivery in the public and private sectors. The Act assigns the responsibilities of the public health system to the three tiers of government – federal, state and local. In these tiers, the health system is organised into three levels: the primary, secondary, and tertiary levels (Federal Republic of Nigeria, 2014).

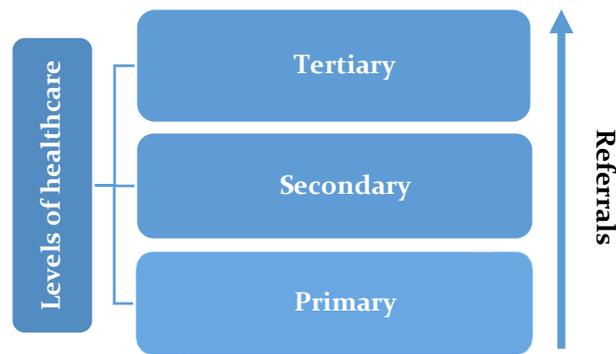


Figure 1: Levels of healthcare delivery and facilities in Nigeria

Figure 1 illustrates the 3-level healthcare system in Nigeria. The first level of care is primary healthcare. It is the closest to the population and the first port of call for the community to access essential health services. Primary healthcare consists of primary health centres (PHCs) in local government areas, private clinics, local pharmacies, traditional medicine, chemists and itinerant drug sellers (Federal Government of Nigeria, 2018). Traditional birth attendants (TBAs) work as an alternative to nurses/midwives, mostly in rural PHC settings. Although TBAs do not receive formal medical training, they provide maternal and child healthcare services to women living in rural areas because they are affordable and accessible (Amutah-Onukagha et al., 2017). The TBAs and itinerant drug sellers are usually not regulated in the country. However, the Lagos State Government Lagos State Traditional Medicine Board claimed it has registered over 7000 traditional medicine practitioners, which comprise TBAs, bonesetters and faith-based birth attendants as of 2020 (Omotayo & Udosen, 2020). The main mode of service delivery in primary care is outpatient. Any complicated cases are referred to secondary care facilities.

The second level of care is secondary healthcare, which comprises government-owned general and specialist hospitals and private hospitals/clinics in various Nigerian states. The main modes of service delivery in secondary care are outpatients and inpatients. Referral of critical cases is made to tertiary care facilities.

The third level of care is tertiary healthcare, which comprises state and federal university teaching hospitals, federal medical centres (in states with no federal teaching

hospitals) and the national hospital in the Federal Capital Territory, Abuja. The modes of service delivery are outpatients and inpatients. They receive referrals from mostly secondary care and rarely from primary care facilities.

1.5.3 Healthcare facilities

Healthcare facilities are generally categorised into primary, secondary and tertiary health facilities. A substantial number of these health facilities are spread across the three levels of care and are publicly or privately owned. The distribution of these facilities will determine the level of access to care for the population (Makinde, Sule, Ayankogbe, & Boone, 2018). Ideally, a fair distribution of health facilities will promote equitable access to care among the citizens. In reality, the current state of the facilities needs to be considered to ensure the quality of the care access. The second edition of the National Strategic Health Development Plan reports on the distribution of healthcare facilities and their conditions. It is alarming to note that 80% of the facilities were purportedly not in good shape to a varying degree. This situation is due to a poor culture of maintenance, which is not unfamiliar to the Nigerian polity (Federal Government of Nigeria, 2018). Recent data on the number of health facilities across Nigeria is provided through the Health Facility Register (Federal Ministry of Health, 2019). From this data, Tables 1 and 2 show the distribution of operational health facilities based on the number, ownership (i.e. public and private) and the level of care (i.e. primary, secondary and tertiary) across Nigeria and Lagos State.

Table 1: Number of health facilities by the level of care and ownership across Nigeria

Level of care	Public	Private	Total
Primary	28,113 (95.5%)	6,224 (57.1%)	34,337 (85.1%)
Secondary	1,233 (4.2%)	4,620 (42.4%)	5,853 (14.5%)
Tertiary	101 (0.3%)	57 (0.5%)	158 (0.4%)
Total	29,447 (100.0%)	10,901 (100.0%)	40,348 (100.0%)

It is worth noting that primary care constitutes 85% and 67% of the health facilities in Nigeria and Lagos state, respectively (Tables 1-2). This high percentage of Lagos PHC facilities is not surprising because urban settings are better served than rural areas due to a relatively higher population density in urban areas (World Health Organization,

2017). Moreover, the figures denote the strategic positioning of primary healthcare facilities in delivering essential care services to the broader community.

Table 2: Number of health facilities by the level of care and ownership across Lagos State

Level of care	Public	Private	Total
Primary	412 (90.0%)	1,162 (62.0%)	1,574 (67.5%)
Secondary	43 (9.4%)	710 (37.9%)	753 (32.3%)
Tertiary	3 (0.7%)	3 (0.2%)	6 (0.3%)
Total	458 (100.0%)	1,875 (100.0%)	2,333 (100.0%)

Figure 2 depicts the number of public PHCs in each local government area, with a total of 412 PHCs across Lagos State. Alimosho LGA has the highest number of PHCs because it is the most populous LGA in Lagos State (Kayode, Taiwo, Adetoro, & Sam, 2020).

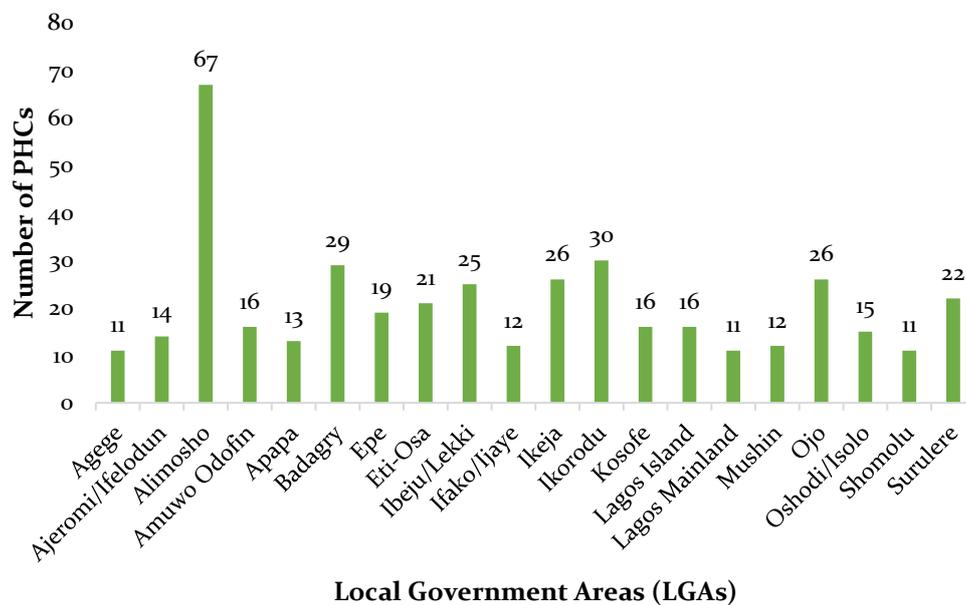


Figure 2: Number of public PHCs in Lagos LGAs

1.5.4 Healthcare workforce

The workforce is crucial to the success or failure of any health system. The availability, skill mix and distribution of the healthcare workforce are instrumental to the performance of the health system and the quality of healthcare service delivery to the population. As with other African countries, Nigeria is plagued with human resources for health (HRH) migration to developed countries such as the UK, US, and Canada. This migration has led to brain drain, uneven distribution and shortage of skilled HRHs

in health facilities, especially in the rural areas of northern Nigeria (Federal Government of Nigeria, 2018).

One key issue to address holistically is the management of health workforce data. There is no up-to-date HRH data in Nigeria, which impacts accurate planning and urban/rural distribution of skilled HRH across health facilities (Federal Government of Nigeria, 2018). There have been efforts by relevant stakeholders to tackle the persistent maldistribution of HRH in the country. One of these efforts is the strengthening of health workforce planning and management. For example, in collaboration with the World Health Organisation (WHO), the Nigerian government has started to develop the Nigeria Health Workforce Profile 2018. This document will provide a better understanding of the size, characteristics and performance of the health workforce. Moreover, it will help produce insights into the gaps and opportunities for strengthening the health workforce (WHO Africa, 2019). An earlier example is the introduction of an integrated human resources information systems (iHRIS) to improve health workforce (HW) management in Nasarawa State. The state government implemented an iHRIS-based HW registry to collect, maintain and analyse the data of primary care employees (Nta et al., 2017).

1.5.5 Rationale for the choice of Festac Primary Health Centre

Festac Primary Health Centre (PHC) is the leading public primary care facility located in Festac Town, Amuwo Odofin Local Government Area (LGA) of Lagos State, Nigeria (Figures 3 and 4). Festac PHC is the headquarters of all 16 PHCs in Amuwo Odofin LGA (Figure 2). It has the highest number of doctors (7) and a wider range of health personnel, including midwives, nurses, a pharmacist, pharmacy technicians, laboratory scientists/technicians, community health officers, community health extension workers, environmental health officers and health attendants/assistants (36) than any other PHC in Lagos State (Federal Ministry of Health, 2019). In 2018, four health information managers were posted to Festac PHC.

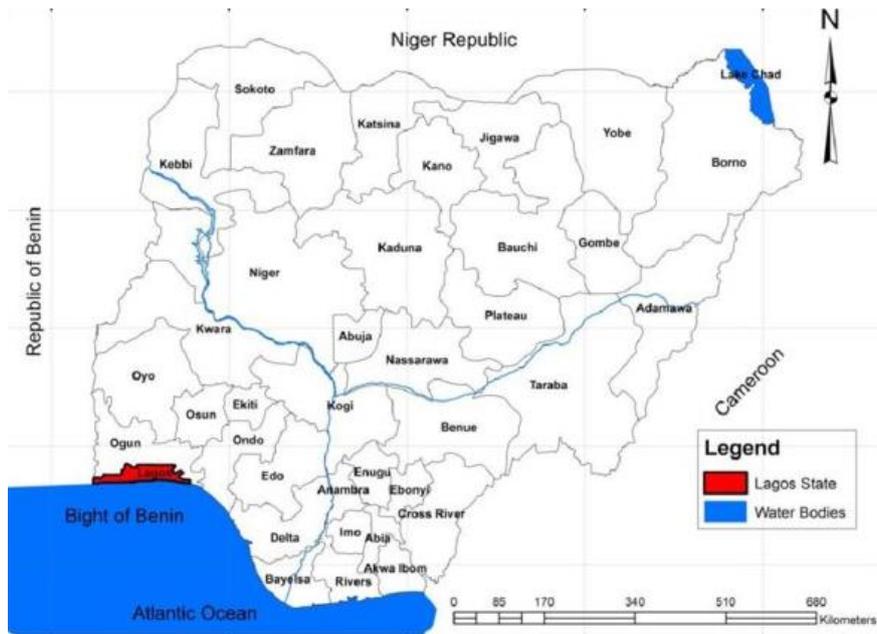


Figure 3: Map of Nigeria highlighting Lagos State (Adeniran, Otokiti, Otokiti, & Durojaye, 2020)

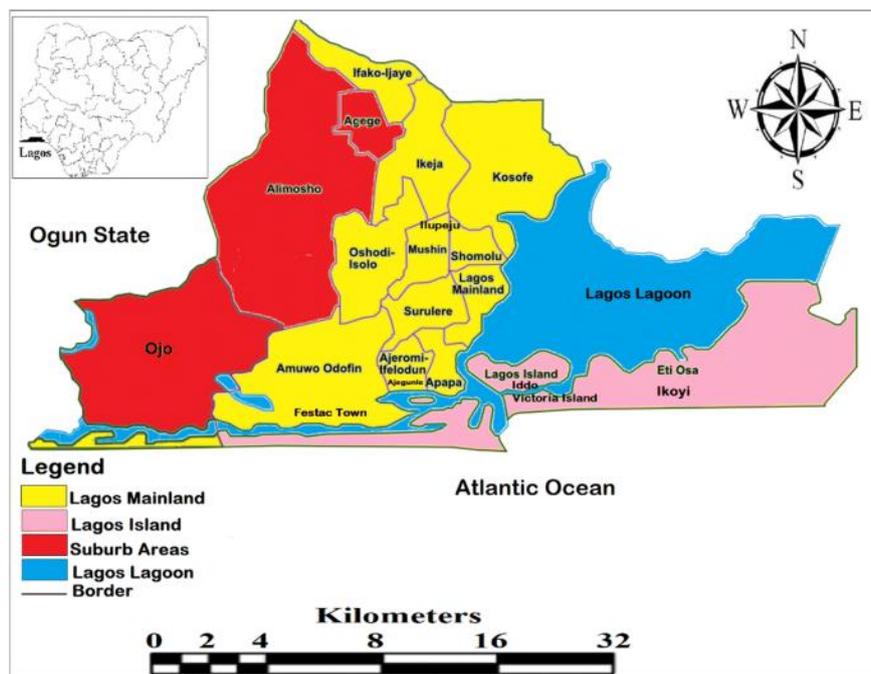


Figure 4: Metropolitan view of Lagos (Lawal, Abdul-Lateef, Ismaila, Yusuf, & Aina, 2020)

Festac PHC is among the few primary care facilities that operate 24 hours and seven days a week, while a vast majority are only operational during weekdays. Health services are delivered free of charge. With the number of healthcare staff, a wide range of services provided, and operation hours, Festac PHC is a flagship public primary care centre in Lagos State known for its transformation to reduce maternal and child health

mortalities (Lagos State Ministry of Health, 2017). Again, the size of the health workforce in Festac PHC is not typical of most PHCs in Lagos, which, in some cases, do not have doctors. With the strength of its workforce, the centre makes fewer referrals to secondary care facilities.

1.6 Maternal and child health in Nigerian primary care

One of the significant health needs in Nigerian primary care, in common with other LMICs, is maternal and child healthcare (MCH) (Ebenso et al., 2018). Women and their children would usually attend the health facility for ANC, delivery, immunisation and family planning services (Mirzoev et al., 2016).

The comprehensive Nigeria Demographic and Health Survey (NDHS) was conducted in 2018 with data on early childhood and maternal (demographics) alongside their respective rates and causes of mortalities. Women of childbearing age fall in the range of 15 to 54 years in Nigeria (National Population Commission (NPC) [Nigeria] & ICF, 2019; World Health Organization, 2017, 2020a). Table 3 shows the infant (<5 years) (UNICEF, 2020) and maternal mortality ratios (UNFPA, 2020).

Table 3: Infant and maternal mortality in Nigeria

Group	Population fraction	Mortality ratio
Infants < 5	20%	117.2 per 1000 live births
Mothers	22%	917 per 100,000 live births

Nigeria population estimate – 206 million (UNFPA, 2020)

Maternal and child health is a crucial aspect of global health that needs urgent attention to achieve the Universal Health Coverage (UHC) targets by 2030 (United Nations Children’s Fund, 2018). One of the main goals of the UHC is for countries to ensure that the population has access to essential quality health services. A recent UNICEF study reported the data on maternal and child mortalities by global regions. For example, in developed regions such as Australia & New Zealand and Europe, under-five mortality rates are 4 and 5 per 1000 live births, respectively. In other developing regions such as Southern Asia and Sub-Saharan Africa, the rates are 44 and 76 per 1000 live births,

respectively (United Nations Children’s Fund, 2018). Interestingly, 56% of deaths in the WHO African Region in 2015 were due to communicable, maternal, perinatal or nutritional conditions (WHO, 2018).

1.7 Digital health implementation in Nigeria

1.7.1 Current realities

The challenges of health IT implementation in LMICs, especially Nigeria, include inadequate infrastructure, limited human capacity, brain drain, lack of enforcement of legislation and policies (political will), insufficient financial investment/incentives and corruption-riddled systems (Federal Ministry of Health, 2016; Mackey, Vian, & Kohler, 2018; Oluoch & de Keizer, 2016; Uzochukwu, Onwujekwe, & Mbachu C, 2015). Despite the funds from WHO and other funding agencies, the implementation is fraught with corruption. Private individuals and organisations in the health system sabotage the funds earmarked for these IT projects (Olaronke et al., 2013). As a result of these acts, the patients/citizens who are beneficiaries do not get the intended quality of care and health outcomes (Mackey et al., 2018). Hence, funding agencies can add to their existing requirements of how implementers will monitor and evaluate the actual use and effect of resources provided. This study proposes a very effective tool to achieve this – Theory of Change (ToC) (see [Chapter 3](#)).

1.7.2 Potential digital health architecture for Nigeria

The building blocks for any digital health architecture (Figure 5) are three main components: *people*, *process* and *technology* (Persse, 2016). These three components are interconnected so that the people are involved in designing the process that the technology intends to transform.

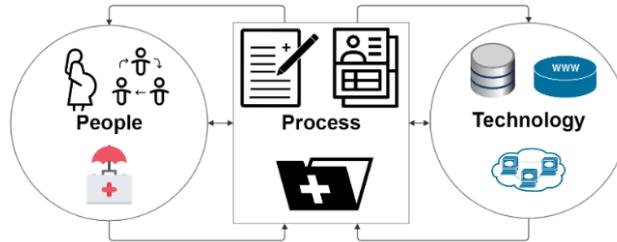


Figure 5: Building blocks for digital health architecture

The *people* component comprises the patients, providers and policymakers or funders. Patients are the service users such as pregnant women and under-five infants who access the health facility for treatment, immunisation and tests. The *process* component consists of the clinical workflow, delivery and design. Clinical workflows should be digitised to ensure efficient and effective health service delivery to patients. Providers should be appropriately involved in the design of the clinical workflow. The design should be done in a way that will simplify the jobs of healthcare professionals. Components under *technology* include functionality, platform and cost.

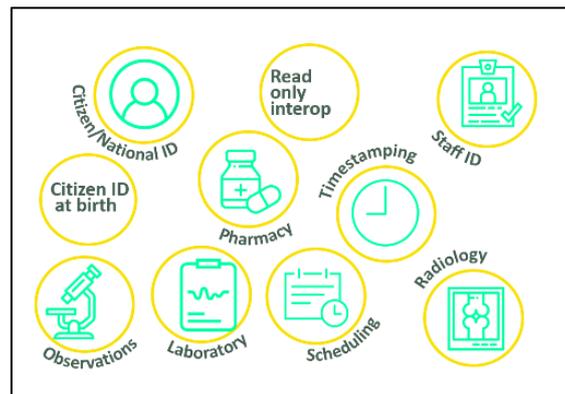


Figure 6: Basic EHR functions

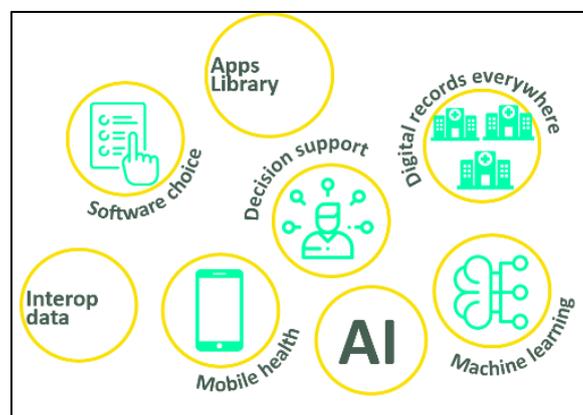


Figure 7: Sophisticated EHR functions

The building blocks are used to build helpful functionality for specific healthcare services. The potential digital health architecture might be feasible in the next ten years (Figures 6-7). It comprises relatively basic features (collecting, processing, storing and presenting medical and clinical information, including patients' past medical histories and current records, pharmacy, laboratory and radiology data) and more sophisticated functionality (clinical decision support systems (CDSS), interoperability and artificial intelligence capabilities) (National Institutes of Health, 2006; Oluoch & de Keizer, 2016; Oluoch et al., 2016).

The envisioned EHR system, if properly implemented, needs rigorous evaluation to ensure its effectiveness on the delivery of quality of healthcare (Rigby et al., 2013). Unfortunately, the evaluation of health IT systems is often overlooked in both developing and developed contexts.

1.7.3 Is the potential digital health architecture feasible?

The current National Health ICT Strategy for Nigeria (Federal Ministry of Health, 2016) has gaps which this study aims to address. For example, the report gave some vital infrastructure recommendations but limited evidence on actual implementations in health facilities. Following informal discussions with certain PHC facilities in urban settings, they are yet to implement EHRs across PHCs but still collect, store and maintain patient and other clinical records manually on paper. Information extracted from the paper medical records is then entered into the National Health Management Information System (NHMIS) in the form of aggregate data by the monitoring and evaluation officers to ensure data quality. Moreover, the report did not include current IT trends such as AI/machine learning, blockchain, and CDSS.

1.7.4 Landscape of ICTs for health in Nigeria

In recent years, governmental and non-governmental stakeholders have made several efforts to strengthen health systems and to drive health improvements in Nigeria. In particular, the government launched the Saving One Million Lives (SOML) initiative to

prevent one million women and infants (under five years) from deaths by ensuring access to vital primary health services (Results for Development Institute, 2014). As a supplementary effort, the Federal Ministry of Health (FMOH) and the Federal Ministry of Communication Technology (FMCT) launched the Information and Communication Technologies for Saving One Million Lives (ICT4SOML). This initiative employed different ICT platforms to enhance maternal and child health (United Nations Foundation, 2014).

To support the ICT4SOML initiative, the UN Foundation prepared a comprehensive report that assessed and catalogued 84 digital health technologies and their role in improving MCH services across Nigeria (United Nations Foundation, 2014). The report considered different aspects of each digital health implementation:

- *SOML programme areas*: essential medicines, immunization, malaria, maternal-child health (MCH), nutrition, and prevention of mother-to-child transmission of HIV (PMTCT)
- *Geographic coverage*: Nationwide, multiple states, single state, local government (LGA) or smaller area and missing area
- *Technology used*: SMS based applications/support platforms, data/internet-based applications, high-speed internet/broadband requiring applications and offline applications
- *Health system functions*: disease surveillance and reporting, registration and vital events, provider training and education, health financing, health information system (HIS), decision support, scheduling and reminders, resource management, communication and patient education and behaviour change
- *Level of scale*: proof-of-concept, pilot, scale-up or at-scale

The programme area with the most ICT for health initiatives is the MCH (63), while nutrition (12) has the lowest. It should be noted that some ICT tools fall under more than one programme area. Despite MCH accounting for most of the initiatives, there remain challenges of funding, poorly trained staff and inadequate infrastructure.

Of the 84 projects, 22 were purportedly implemented nationwide, 18 multiple States, 18 in a single State, 9 in LGAs and 17 implementations have no record of geographical coverage. The prominent technologies implemented are SMS-based (31), data applications (26), web-based portals (24) and pre-loaded applications (23), which is not surprising. As of 2014, the total mobile subscribers was about 127.2 million in a population of 176.4 million (The World Bank, 2021). Hence, a large percentage of the Nigerian population has access to mobile phones, which would enhance the citizens' use of the technologies mentioned above.

Health Information System (HIS) was reported as the most implemented health system function of the ten categories (as shown in the list above). HIS implementations comprise nearly a quarter of all identified ICT4SOML initiatives. The HIS systems are used for collecting, storing and transmitting individual or aggregate health data in health facilities. Typical examples of HIS are the EHR and NHMIS systems.

The levels of scale were determined through the status of the ICT for health projects, whether they are in beta/testing or concluding stages. Of the 84 projects, 79 were either in pilot stages, being scaled up or already at scale. This key finding shows that digital transformations are achievable in Nigeria.

In sum, the inventory could not be regarded as exhaustive because there have been other completed and ongoing digital health projects in recent years. Moreover, some of the initiatives have ceased since the publication of the report.

1.8 Motivation

Infrastructure deficit in developing countries can be attributed to several factors, including economic, social and political. For example, many developing countries have low GDP and per capita income. Despite the meagre resources in these countries, there is vandalism of infrastructure in some cases (Tsokota, Chipfumbu, Mativenga, & Mawango, 2013), which affects progress. Sometimes, governments make policies to

improve infrastructure with no corresponding implementation, perhaps due to corruption, a lack of political will or accountability (Mackey et al., 2018).

Paper health records inefficiencies are commonplace in many health facilities in developing and developed countries. These inefficiencies impact the quality of health service delivery for health practitioners and patients. It takes a lot of work for interested stakeholders to introduce digital health to health facilities locally, nationally and globally. While the ambition of digitisation is being realised in various high-resource contexts, low-resource settings are confronted with infrastructural challenges.

Although there have been successful pilot digital health implementations in developing nations, sustainability issues are commonplace for such deployments.

Health information exchange is a key concern for digital health systems. Despite the progress of digital health implementations in developed and developing countries, there are problems encountered with seamless health information sharing across health systems regionally, nationally and internationally.

These practical issues/factors necessitate the conduct of this study to investigate the potentials of digital health.

1.9 Significance of the research

This multidisciplinary research is relevant because it provides the stakeholders with a theory-based and testable approach toolkit – Theory of Change ([Chapter 3](#)). This toolkit is used in implementing a digital health system in the LMIC context, well known to be a complex intervention even in high-income countries. Furthermore, the study systematically and logically demonstrates extensive evidence-based methods and findings, providing robust evidence for the relevant stakeholders to adopt in their settings. The multidisciplinary nature of this study blends information systems with health, evaluation and international development in understanding and addressing real-world problems. This approach is vital because the complexities of digital health implementation are best addressed when viewed from different angles. If appropriately

implemented, the system will ensure confidence for the users and produce the desired outcomes for the population.

1.10 Research aim and questions

The preceding sections have shown that (a) paper records remain a serious cause of inefficiencies in Nigerian healthcare (1.2, 1.8 and 1.7.3), (b) MCH is an agreed priority (1.6), and (c) sustainability is an acknowledged problem in all development initiatives (1.3). Therefore, this research aims to establish how the benefits of digital health implementation can be realised in Nigerian primary care, and the selected research questions (RQs) are:

RQ1: How can electronic health records (EHR) effectively benefit the delivery of maternal and child healthcare (MCH) in Nigeria?

RQ2: What are the sustainable factors of digital health implementation for maternal and child healthcare, learning from experiences in developing and developed nations?

RQ3: What are the priorities, preconditions and barriers to implementing an interoperable EHR in low- and middle-income countries?

An interoperable EHR is an EHR system that can communicate or exchange information across digital health systems, healthcare organisations, and geographical areas (Dobrow, Bytautas, Tharmalingam, & Hagens, 2019). This system will typically be designed and implemented with the relevant interoperability standards (e.g. FHIR, openEHR and OHDSI) and terminologies/vocabularies (e.g. SNOMED CT, ICD-X, LOINC and RxNorm) to enable it to share data (including patient records, clinical information and routine/research data) with other health IT systems. More details on EHR interoperability can be found in [Section 5.7](#).

1.11 Structure of the thesis

Chapter 1 presents the introduction to the thesis, and Chapter 2 discusses the relevant literature. Chapter 3 provides insights into the theoretical framework underpinning this study. Chapter 4 describes the primary research methodology alongside the philosophical perspective guiding this research. Chapter 5 demonstrates the study results from all the research methods used. Chapter 6 critically discussed the implications of the research findings. Chapter 7 concluded the study along with its original contribution to knowledge and future directions.

Chapter 2: Literature review

2.1 Overview

This chapter details the protocol for the systematic review (Section 2.2), which serves as a precursor for the main systematic review. Section 2 extensively delves into the systematic review showing the findings described in the protocol. Section 3 assesses the knowledge gaps and anticipated contribution from the literature review findings.

2.2 Protocol for systematic review

2.2.1 Background of review

Electronic health record (EHR) systems as digital health interventions have been implemented by health systems. Hospitals and primary healthcare centres (PHCs) across the globe have implemented these systems to facilitate clinical processes and ensure that maternal and child healthcare (MCH) services are delivered to patients effectively. In spite of the number of studies that have been published on the effectiveness of EHR, the evidence of the benefits of many implementations and their sustainability remains mixed. A vast amount of the published evidence is from high-income countries, but little evidence is from low- and middle-income countries (Reis et al., 2017; Sevick et al., 2017). Ideally, PHCs would aim to deliver services to patients efficiently with digital health, but decisions on adopting and implementing the right system have to be made. Sometimes, the providers are made aware of the benefits that digital health systems such as EHRs could accrue to their PHC processes. Still, there is no guarantee whether the implementation of such systems is fit for purpose. (Luzi, Pecoraro, & Tamburis, 2016; Reis et al., 2017). Thus, there is the need for solid evidence of digital health benefits for MCH in primary care settings in LMICs, especially Nigeria. The evidence from this review will provide the relevant stakeholders with helpful information to make informed clinical decisions and fulfil the digital health vision of the Universal Health Coverage (UHC) 2030 for Nigeria.

2.2.2 Objective

The overarching purpose of the proposed systematic review is to carry out a rigorous analysis of the evidence of the benefits of digital health implementations in Nigeria. The specific objective is:

- To assess the studies that focus on the effectiveness of digital health implementations for delivering maternal and child health in Nigeria.

2.2.3 Methods and analysis

This protocol complies with the requirement of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Protocol PRISMA-P 2015, including the *population, interventions, comparators, outcomes* and *study design* (PICOS) elements and the PRISMA flowchart (Moher et al., 2015). The PICOS elements will be used to highlight the inclusion and exclusion criteria for the paper search and selection process. The PRISMA flow diagram depicts how studies are identified, screened and assessed for eligibility. Based on the assessment, the diagram also shows the number of included and excluded studies (with reasons for exclusion) for qualitative/quantitative synthesis.

2.2.3.1 Conceptual framework

The findings from the included studies will be analysed using a simple *logic model* because it is linear, digestible and usable (Rogers, 2008). A logic model is a theory-based framework used in evaluating and summarising how an intervention works by identifying pathways from inputs/activities to intended outcomes (Rogers, 2008). Logic models are usually graphical representations that outline the inputs, activities, outputs, outcomes and impact of complex interventions (Maden et al., 2017).

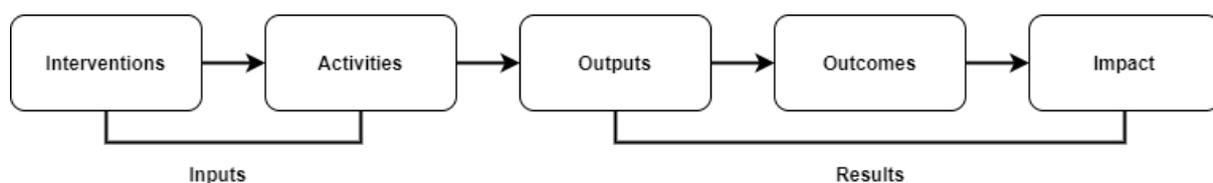


Figure 8: A simple logic model

Although the simple logic model (Figure 8) does not account for the subtleties of findings, its simplicity helps to distil disparate findings from the included papers. The logic model will be developed to supplement/strengthen the known review methods (e.g. PRISMA and PICOS) by providing additional insights for the digital health implementations reported in the included studies.

Table 4 summarises the PICOS elements alongside the inclusion and exclusion criteria for studies in the review.

Table 4: Summary of the PICOS elements included and excluded in the systematic review

	Inclusion criteria	Exclusion criteria
Population	Primary healthcare centres (PHCs) that provide maternal and child healthcare (MCH) services in Nigeria	Clinical areas other than MCH Studies focusing on secondary and tertiary care Studies outside Nigeria
Intervention	Digital health interventions including open-source and commercial electronic health record (EHR) and mobile health (mHealth) systems that aim to maintain and process clinical and patient records	Paper-based health record interventions Manual process improvement interventions
Comparators	PHCs who have not implemented any form of digital health	N/A
Outcomes	<i>Primary:</i> Effectiveness of digital health implementations for MCH in Nigerian PHCs <i>Secondary:</i> Sustainability measures, Interoperability measures, efficiency measures, productivity measures, health outcomes, implementation lessons	N/A
Study design/type	Studies or literature reviews published from 2005 to 2018, with a geographical restriction to Nigeria Effectiveness studies	Abstract-only reports without references, commercial studies, party political statements, general discussion papers, magazine or newspaper articles, withdrawn abstracts or articles, study protocols without implementation data.

2.2.3.2 Search and selection strategy

The following databases will be searched for relevant articles: Web of Science, Cochrane Library, PubMed, EBSCO and MEDLINE. The search strategy was developed iteratively, based on trial searches, using the PICOS framework (Moher et al., 2015), with a university librarian and considering the methods section of previous systematic literature reviews in the field. The search strategy is displayed in Table 5, but this review will only apply to RQ1. The search strategy combined Boolean operators (AND, OR) for the search terms as follows:

((electronic medical records OR electronic health records OR digital health OR health information systems OR health information technology OR e health OR ehealth OR e-health) AND (effect OR effects OR effectiveness OR efficiency OR efficacy OR efficient OR benefit OR benefits) AND (implement) AND (maternal health OR child health OR maternity OR infant OR mother) AND (nigeria OR lagos OR Abuja))*

Studies published in English will be included in this review if they have evidence of “effectiveness” and “maternal and child health” in Nigerian primary healthcare centres that have implemented any form of digital health. The date range was chosen for the search parameters because the Nigerian health sector was a latecomer to digitisation. The review will exclude sources and papers without full-text articles. Papers that research interventions that are not electronic or digital will also be excluded.

All the published studies, as described above, from 2005 to 2018 will be considered because most articles found on health IT in Nigeria were published from the early 2000s when IT began gaining traction in the developing nation (Idowu, Cornford, & Bastin, 2008). The included studies will be screened based on previous work in health informatics. The studies selection will be managed using Mendeley Desktop v. 1.19.4 and Mendeley web.

Table 5: Search strategy for research questions (RQs)

	Research questions (RQs)	Search strategy
RQ1	How can EHR implementation effectively benefit the delivery of maternal and child health in Nigeria?	Open review/search for all study designs.
RQ2	What are the sustainable factors of digital health implementation for maternal and child healthcare, learning from experiences in developing and developed nations?	Open review/search for all study designs.
RQ3	What are the priorities, preconditions and barriers to implementing an interoperable EHR in Nigeria?	Directed review/search of policy and strategy documents

2.2.3.3 Population

As illustrated in Table 4, published studies that include primary healthcare centres (PHCs) in Nigeria that provide maternal and child healthcare (MCH) services will be assessed for inclusion. The review will not include studies covering clinical areas other than MCH, secondary and tertiary care, and outside Nigeria.

2.2.3.4 Intervention

The review will include original papers that examined digital health interventions, including open-source and commercial EHRs and mobile health (mHealth) systems, which aim to maintain and process clinical and patient records. Studies having paper-based health records and manual process improvement interventions will be excluded from the review.

2.2.3.5 Comparators

The only comparator is PHCs that have not implemented any form of digital health.

2.2.3.6 Outcomes

The primary outcome measure will be the effectiveness of digital health implementations for MCH in Nigerian PHCs. Secondary measures will include

sustainability, interoperability, efficiency, productivity, health outcomes and implementation lessons.

2.2.3.7 Study design

Studies published from 2005 to 2018, with a geographical restriction to Nigeria. The study design will include effectiveness studies, abstract-only reports without references, commercial studies, party political statements, general discussion papers, magazine or newspaper articles, withdrawn abstracts or articles. Study protocols without implementation data will be excluded.

2.2.3.8 Data extraction

The review will independently extract data from the included studies using a data extraction form developed based on previous reviews and the aim of the review. The following information will be extracted:

- Author and reference
- Study characteristics
 - Study designs/types (e.g. pre/post-intervention, quasi-experimental)
 - Research methods (quantitative, qualitative, mixed methods)
 - Data collection
 - Healthcare settings (e.g. rural or urban)
 - Level of healthcare (e.g. primary care, secondary care)
 - Target population (e.g. mothers, midwives, nurses)
 - Health needs/conditions (e.g. maternal and child health, antenatal care)
- Study objectives
- Geographical areas where the study took place (e.g. Nigeria, Lagos, Abuja)
- Form of digital health intervention (e.g. eHealth, mHealth, EHR)
- Outcome measures (Primary and secondary, e.g. maternal mortality and morbidity, newborn and child mortality and morbidity, immunisation rates, and effectiveness of interventions),

- Authors' summary of results,
- Outcomes and conclusions

2.2.3.9 *Quality assessment and risk of bias*

Quality appraisal checklists will be used to assess the internal and external validity of studies as appropriate for each study type. One reviewer will assess each paper, and the other reviewer will check for accuracy. Low-quality articles may not be excluded from the review as they can inform the model where higher quality evidence is not found. The Logic Model will reveal the strength or weakness of each piece of evidence, followed by a summary describing the quality of the included studies.

2.2.3.10 *Data synthesis and analysis*

The review will adopt a narrative synthesis approach in summarising and explaining the findings from multiple studies with diverse study designs based on the data extracted. This approach will summarise the current knowledge from research evidence relating to the review question to inform policy and practice (Popay et al., 2006).

Following the narrative synthesis, the logic model will be used to analyse the included studies further. The included papers will be examined, and information will be drawn as they relate to the components of the logic model alongside underpinning evidence (Baxter et al., 2014; Rogers, 2008). For example, the first component of the logic model (interventions) will be expanded by extracting elements of the interventions described across the included papers.

2.2.4 *Ethics and dissemination*

There is no ethical approval for the systematic review because it will be secondary research on existing studies. The review draft will be published as a peer-reviewed journal article. Findings might be presented at conferences and be shared with relevant health stakeholders.

2.2.5 Discussion

The study will include only studies conducted in the Nigerian health context for extraction. However, studies from other countries will be used to inform other aspects of the systematic review. Also, since the review will examine papers published in English, there are relevant papers that may have been published in different international languages, which could improve the quality of the review. Nonetheless, English is the official language of the review context.

2.3 Results

From the review protocol in [Section 2.2](#), this section demonstrates the results of the systematic review conducted.

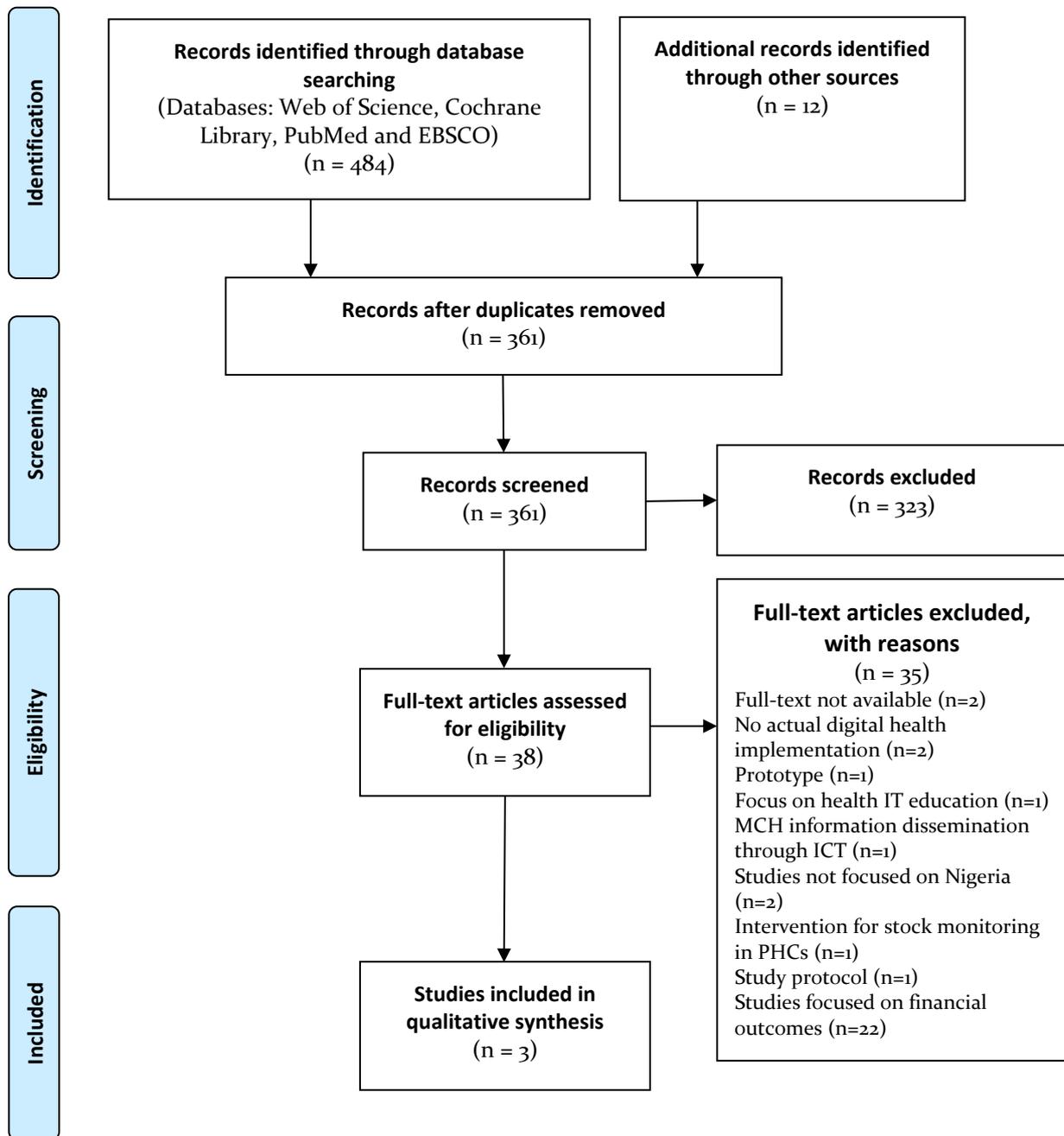
2.3.1 Search results

As shown in [Figure 9](#), the search yielded a total of 361 articles (484 through a search of databases – see [Appendix 2](#)) after removal of duplicates and 12 articles through snowball search. Following a full-text screening, a total of three articles were eligible and included. Articles were excluded based on the following reasons: no access to full-text, non-IT intervention, no actual digital health implementation, prototype IT intervention, focus on health IT education, studies not focused on Nigeria, dissemination of MCH information through ICT, studies focused on financial outcomes, systematic reviews and review protocols without implementation data.

2.3.2 Study characteristics

[Table 6](#) shows the characteristics and results of studies that reported the effectiveness of digital health for maternal and child healthcare in Nigeria. Studies addressed various MCH needs such as antenatal care, child and a combination of conditions (Mcnabb, Chukwu, Ojo, & Shekhar, 2015; Obasola & Mabawonku, 2018; Odetola & Okanlawon, 2014). The contexts in which the implementation studies were carried out are split into urban and rural settings. The study designs were pre/post-intervention, quasi-

experimental and descriptive survey. All the included studies were conducted in Nigeria.



Outcomes of the systematic review of literature by identifying, screening and analysing records in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram.

Figure 9: PRISMA flowchart for the selection of studies

Table 6: Study characteristics

Author	Country (state)	Study objectives	Study type/design	Research method	Data collection/ analysis	Healthcare setting	Level of healthcare	Target population	Health need / condition
McNabb et al., 2015	Nigeria (Abuja & Nasarawa)	Aim: To assess whether the introduction of a mobile application had an effect on the quality of antenatal care services provided by frontline community health extension workers (CHEWs). Objectives: To determine if introducing the mobile app: 1) improved the quality of ANC services provided, and 2) improved client satisfaction with ANC services provided.	Pre/post-intervention study	Quantitative and qualitative	Quality score (25 indicators), Client exit interviews (266 participants); Independent sample t-test & Chi-Square test	Urban (10 PHCs)	Primary care	CHEW, Antenatal care client/patients	Antenatal care (ANC)
Odetola & Okanlawon, 2014	Nigeria (Oyo)	To explore the knowledge and perception of nurses about m-health's effectiveness in primary health care facilities in the South senatorial district in Oyo State.	Quasi-experimental study	Quantitative	Validated 25-item questionnaire, Chi-square and ANOVA	Rural (PHCs in 4 local government areas)	Primary care	Nurses and Midwives	Antenatal care
Obasola & Mabawonku, 2018	Nigeria (Imo, Ondo, Kaduna, Gombe)	To investigate mothers' perceived usefulness of ICT and MCH information disseminated through e-health projects in Nigeria.	Descriptive survey	Quantitative and qualitative	Questionnaire (1001 mothers), focus group (4 sessions of 30 mothers); convenience sampling technique	Rural and urban (9 PHCs)	Primary care	Mothers	Maternal and child health

Table 7: Summary findings from included paper

Author	Digital health intervention	Summary	Outcomes and conclusions
McNabb et al., 2015	mHealth: CommCare mobile platform and decision support application	Overall, the quality score increased from 13.33 at baseline to 17.15 at endline ($p < 0.0001$), with the most significant improvements related to health counselling. Overall client satisfaction, as measured by the proportion of clients who said they were very satisfied with the ANC services, increased from 75% at baseline to 83% at endline ($p < 0.05$). The greatest improvements in the quality of services from baseline to endline were in the areas of client education and counselling.	The study has many advantages in contributing to the growing field of evidence surrounding mHealth interventions in low and middle-income countries. First, the study assessed a project implemented in real conditions of health facility operations in Nigeria, not based on assumptions or modelling. No other program inputs to the supply chain, additional training of health workers or support for clients to attend services were implemented in the project, highlighting the effect the mHealth application alone had on the quality of services.
Odetola & Okanlawon, 2014	mHealth nursing intervention (educational training for nurses to use mobile health)	Findings from the study revealed that though there was a poor level of knowledge at the baseline before nursing educational training, a significant improvement was recorded immediately after the training signifying an appreciable acquisition of the knowledge and skills of mobile health nursing intervention and focused antenatal care.	The study was effective as it improved the knowledge and perceived effectiveness of m-health among PHC nurses. However, the improvement dwindled after 6 months. Thus, similar training and retraining should be conducted periodically to update nurses' knowledge and improve clients' access to quality health information, education and therapeutic communication.
Obasola & Mabawonku, 2018	e-health and m-health interventions	Mobile phones were viewed as useful (35.0%) or very useful (42.2%) and radio as useful (34.8%) or very useful (57.5%), but they expressed a negative perception towards the use of DVD/TV (Not useful, 66.5%) and the Internet/computer (Not useful 67.7%). Mothers' perception of MCH information disseminated was also positive. They reported the need for more MCH information products in local languages using acceptable ICT.	Findings from this study revealed that e-health interventions for MCH could improve access to health information, influence pregnant women to adopt safe MCH practices, encourage prompt patient diagnosis, and increase the utilisation of health facilities. Mobile phones are useful and acceptable tools for improving mothers' access to MCH information. The use of at least two different channels, radio and mobile phone, is important, particularly when Internet access may be less accessible. The preference for modes of communication about maternal and child health information (and languages of presentation) may vary considerably across different communities.

2.3.3 Critical analysis of studies

Table 7 provides a summary of findings from the included studies. This review critically discusses the three selected studies as follows.

Study 1 (Mcnabb et al., 2015)

This study identifies the mHealth intervention introduced to improve ANC services delivery in primary care settings. It highlighted the significant roles of CHEWs in filling the gap of highly skilled HCPs to deliver ANC to clients/patients. The pre/post intervention study applied a robust mixed methods strategy to assess the intervention's significant effects on the ANC services provided and on client satisfaction. In the light of the study design, the baseline and endline measurement criteria were instructive in that it was easy to compare the study outcomes before and after the implementation of the intervention. The validity of statistical inference is apt in generalising to other clinical areas other than maternity and other primary care settings, albeit the sample size is arguably small. Despite the limited sample size, the mixed methods used in the study gave a valid outlook to the findings. Also, because the study was conducted in ten PHCs in urban settings, there are lessons that PHCs can learn in similar settings. This study is particularly relevant considering the rate of maternal mortality in Nigeria. Although the study did not evaluate the impact of the intervention on health outcomes, it examined the usefulness of the mobile app for ANC service delivery and client satisfaction. It is challenging to measure satisfaction over a given period because people are dynamic and have changing moods, especially the peculiarities of pregnancy. At the same time, quality measurement is tricky due to people's subjectivity in assessing the quality. However, the study presented an easy-to-follow quality score analysis, which gives some confidence for the quality of care assessment.

Study 2 (Odetola & Okanlawon, 2014)

This quasi-experimental study describes the outcomes of mHealth nursing intervention between the experimental and control groups over 11 months. It hypothesises that there

was a significant improvement in the knowledge and perception of nurses about the effectiveness of mHealth after training. The study's findings showed a significant improvement among the nurses immediately after the intervention, but it declined as the months went by. It was suggested that more training and retraining should be done periodically to sustain the improvement achieved from the intervention.

Professional background and the experience of nurses and midwives influence health outcomes because pregnant women can receive a reliable quality of care. Due to the shortage of skilled frontline HCPs in Nigeria, especially in rural primary care settings, these skills and experience are beneficial to the delivery of MCH in those settings. The HCPs are intellectually capable and better positioned to using the mHealth intervention with the relevant training. Interestingly, about 55% of the HCPs, such as the chief nursing officers (CNOs) and assistant chief nursing officers (ACNOs), are near retirement, leaving healthcare delivery in the hands of young and often inexperienced HCPs, while the senior ones focus on health policy. On the one hand, the experience of the senior HCPs will help the junior HCPs handle technical health issues. In contrast, the tech-savvy potentials of the young HCPs will influence their use of mobile health in delivering efficient care.

There is a need for training nurses and midwives in primary health centres (PHCs) to use digital health, especially at the point of care. The technologies manage health data in portable ways, introducing efficiencies if HCPs are aware of their effectiveness and trained to use them for patient benefit. For example, it will be helpful to obtain ANC and immunisation data of clients in electronic format as this will make audit tracking and managing appointment reminders easier for both the HCPs and clients. Hence, the study noted the need for HCPs to acquire computer and mobile health nursing skills. On a larger note, these skills should be embedded in the medical school curriculum to better prepare students for the real world. Understandably, there is a gap between theory and practice, but theories can inform practice.

When the HCPs (community health nurses) are empowered to use mHealth, they can provide quality health education to pregnant women, which in turn helps them make

informed choices about their health. These efforts can be sustained by continual training and retraining of HCPs and the effective collaboration among all relevant stakeholders to address the barriers mitigating against the success of the intervention. Certain factors inhibit the mHealth intervention's effectiveness, such as low literacy level of users, inadequate infrastructure, unstable power supply, lack of funding to sustain the intervention, and policy instability. Poor literacy of mothers is a huge barrier to accessing quality and personalised healthcare through mHealth (voice or SMS). Again, sustainability issues such as leadership, financing and policy instability are barriers to successful digital health implementation. Hence, there needs to be an unwavering commitment from the relevant government authorities to make policies and allocate funds to sustain the intervention in PHCs. This commitment will improve the quality of care for citizens. Although the descriptive study highlighted the demographics, it did not provide the number of PHCs used.

Study 3 (Obasola & Mabawonku, 2018)

The outcomes measures and target population were not explicit. This study focused on mothers rather than HCPs' perception of the usefulness of eHealth. The study proposed that a combination of ICT tools be used for disseminating MCH information considering the dispositions of mothers towards a variety of devices such as mobile phones, radio and TV. Implementers of eHealth should adopt a user-centric and multi-technology approach while implementing health IT projects. The consumer of the MCH services differs in backgrounds and access with some living in rural settings having minimal infrastructure, poor literacy and language barriers. Not engaging the target group in the design of eHealth projects will affect the adoption of such intervention because mothers have diverse perceptions of ICT. Hence, for the intervention to be fit for purpose, those perceptions must be considered to achieve success.

2.3.4 Logic model for included papers

The classification process commenced by examining whether a specific finding from a study should be placed in Pathway A, B, C, D or E. Three findings were placed in

Pathway A (Intervention), 24 in Pathway B (Activities), 5 in Pathway C (Outputs), 16 in Pathway D (Outcomes) and 7 in Pathway E (Impact). The comparing and combining of the specific findings resulted in several general findings within each pathway. The general findings are assigned an individual code (i.e. pathway character plus number) and the relevant code is indicated alongside each specific finding in [Appendix 3](#). Findings that were only seen in one article and thus lacking support were discarded.

Pathway A – Interventions

The predominant digital health intervention in all three studies is mHealth (Table 8). This suggests the growing access to mobile technologies in Nigeria.

Table 8: Pathway A – Interventions findings

General findings	Finding code	Paper
mHealth intervention.	A1	McNabb et al., 2015
mHealth nursing intervention	A1	Odetola & Okanlawon, 2014
e-health and m-health interventions	A1	Obasola & Mabawonku, 2018

Pathway B – Activities

A variety of activities was carried out in the studies, but the common ones include healthcare workers giving consent, the use of pre-tested questionnaires for data collection and data analysis using statistical tools to test effectiveness (Table 9).

Table 9: Pathway B – Activities findings

General findings	Finding code	Paper
Community Health Extension Workers and supervisors in Primary Health Centres were trained to use the mobile app.	B1	McNabb et al., 2015
Participants gave consent to participate in the study.	B1	Odetola & Okanlawon, 2014
1001 mothers who were attending maternity clinics at Nine public health facilities in Ondo (4), Imo (1), Kaduna (2) and Gombe (2) States were purposively selected for the descriptive survey.	B1	Obasola & Mabawonku, 2018
Participants gave verbal consent to participate in the study	B2	McNabb et al., 2015
A thoroughly validated self-developed 25-item questionnaire was pre-tested and validated at Cronbach's Coefficient of 0.8.	B2	Odetola & Okanlawon, 2014
A questionnaire and focus group discussion (FGD) guide were used to elicit information from mothers involved in ICT based projects in the study locations.	B2	Obasola & Mabawonku, 2018
A quality score consisting of technical and counselling elements was developed.	B3	McNabb et al., 2015
The data was collected over 11 months among nurses who were randomly assigned into experimental and control groups.	B3	Odetola & Okanlawon, 2014
The questionnaire for the study was developed based on clues from the UTAUT scale for measuring the perceived usefulness of an information system.	B3	Obasola & Mabawonku, 2018
Effectiveness was assessed by comparing scores from client exit interviews collected at baseline and one year after the intervention at endline.	B4	McNabb et al., 2015
The level of knowledge about m-health nursing intervention was calculated and compared statistically using chi-square at baseline	B4	Odetola & Okanlawon, 2014
The questionnaire was pretested, and the reliability coefficient calculated using Cronbach Alpha was 0.86.	B4	Obasola & Mabawonku, 2018
A baseline and endline client exit interview tool was adapted from the Measure DHS tool used for service provision assessment.	B5	McNabb et al., 2015
Mean values were computed in both experimental and control groups with $p < 0.05$	B5	Odetola & Okanlawon, 2014
Research assistants who could speak the local languages were employed for the FGD sessions recorded using a mobile device.	B5	Obasola & Mabawonku, 2018
Data collectors were trained to administer the exit interviews at baseline and endline.	B6	McNabb et al., 2015
Nurses' professional background's influence was explored on the variables to determine any significant relationship	B6	Odetola & Okanlawon, 2014
Data collection spanned over nine months.	B6	Obasola & Mabawonku, 2018
Interviewers visited sites and conducted interviews on as many ANC days as necessary to reach the individual site target.	B7	McNabb et al., 2015
Ethical approval was obtained from the University of Ibadan Ethics Committee.	B7	Obasola & Mabawonku, 2018
The mHealth project was implemented.	B8	McNabb et al., 2015

Informed consent of the participants was obtained.	B8	Obasola & Mabawonku, 2018
At baseline, HCWs gave unstructured health talks prior to seeing individual clients for ANC days.	B9	McNabb et al., 2015
The quantitative data were analysed using descriptive statistics, While the qualitative data were transcribed into English and content-analysed.	B9	Obasola & Mabawonku, 2018

Pathway C – Outputs

Only two studies specified their outputs, which centred on immediate participants' responses from the activities around the intervention in Table 10.

Table 10: Pathway C – Outputs findings

General findings	Finding code	Paper
The mobile app provided decision support functionality for all 25 quality attributes.	C1	McNabb et al., 2015
Nurses acquired knowledge of m-health's effectiveness in healthcare practice.	C1	Odetola & Okanlawon, 2014
Mothers' perceived usefulness of ICT and maternal and child health (MCH) information disseminated using ICT in Nigeria was positive.	C1	Obasola & Mabawonku, 2018
Standardized health counselling messages were introduced through this intervention and have the potential for affecting positive change in health behaviours that can affect maternal and child health outcomes.	C2	McNabb et al., 2015
The mothers indicated that phone and radio were the most useful of all ICT tools.	C2	Obasola & Mabawonku, 2018

Pathway D – Outcomes

All studies reported their outcomes, indicating a mix of positive and negative results from the use of the interventions (Table 11). Odetola and Okanlawon (2014) reported more extensive outcomes from the nursing interventions.

Table 11: Pathway D – Outcomes findings

General findings	Finding code	Paper
The quality score increased at baseline and endline, with the most significant improvements related to the ANC and health counselling domains.	D1	McNabb et al., 2015
Most nurses had neither heard about nor seen m-health nursing intervention in use before the study.	D1	Odetola & Okanlawon, 2014
The perception of the mothers on mobile phones and radio was positive, but that of the computer was negative	D1	Obasola & Mabawonku, 2018

The intervention seemed to have a particularly strong effect on counselling provided by the CHEWs.	D2	McNabb et al., 2015
Results after 3 months of the nursing intervention (P ₁) revealed an appreciable improvement in the level of knowledge with mobile health nursing.	D2	Odetola & Okanlawon, 2014
The quantitative data revealed improved knowledge about health issues surrounding pregnancy and childbirth (97.3%). The mothers were of the view that the use of ICT disseminated MCH information helped them to stay healthy in pregnancy (94.6%)	D2	Obasola & Mabawonku, 2018
Improved quality scores related to the frequency at which CHEWs performed more technical aspects of care, such as measuring blood pressure, obtaining blood or urine samples, and certain physical examination screenings for signs of preeclampsia.	D3	McNabb et al., 2015
Perception about mobile health effectiveness among the experimental group with a similar trend among the control group as well revealing high level of significance for mobile health nursing and perception of mobile health.	D3	Odetola & Okanlawon, 2014
Results from the FGD sessions with the mothers in Imo State revealed a positive perception towards the Internet as an important source of MCH information and that it provided the opportunity for them to access health information at their convenience.	D3	Obasola & Mabawonku, 2018
Repeated measures ANOVA carried out revealed a significant difference in the mean scores in the knowledge of m-health	D4	Odetola & Okanlawon, 2014
Findings from the FGD in Ondo, Gombe and Kaduna States were different. Mothers in the three states indicated a positive preference for mobile phones because of their relevance in meeting specific health information needs (especially during emergencies).	D4	Obasola & Mabawonku, 2018
The formulated hypothesis that stated that there would not be any significant difference in knowledge was failed to be accepted at P ₁ but accepted at P ₂ .	D5	Odetola & Okanlawon, 2014
The findings from mothers' responses during the FGD sessions also showed that some mothers were of the view that, with the exception of interactive radio or television programmes that incorporate feedback through phone calls, MCH information from radio and television was usually limited. They opined that it would be better to have more interactive TV or radio programmes in different dialects to provide (pregnant women) more opportunities to clarify issues about MCH.	D5	Obasola & Mabawonku, 2018
Major findings thematically revealed network/service failure, inconsistent financial support by the government, and policy instability.	D6	Odetola & Okanlawon, 2014
No significant relationship was observed between all nurses' professional backgrounds and their knowledge of m-health (p>0.05) at baseline, P ₁ and P ₂ levels.	D7	Odetola & Okanlawon, 2014
There was no significant relationship between all nurses' professional backgrounds and their perception of the effectiveness of mobile health intervention (p>0.05) at baseline, P ₁ and P ₂ levels.	D8	Odetola & Okanlawon, 2014

Pathway E – Impact

The impact observed from the studies is related to the quality and improvements experienced by the participants (Table 12). The extent to which the impact will be sustained needs further clarifications.

Table 12: Pathway E – Impact findings

General findings	Finding code	Paper
m4Change (mHealth) intervention was in fact associated with a higher quality of ANC scores, with these improvements observed in multiple domains of care.	E1	McNabb et al., 2015
Perceived effectiveness of m-health intervention among the Community Health Nurses in the rural communities despite all the identified barriers.	E1	Odetola & Okanlawon, 2014
Mothers use ICT to receive maternal health information and adopt MCH information promoted through ICT once they are convinced that it will help to improve their health.	E1	Obasola & Mabawonku, 2018
Assessed a project implemented in real conditions of health facility operations in Nigeria, not based on assumptions or modelling.	E2	McNabb et al., 2015
m-health would be more effective in urban areas where all the barriers are controllable.	E2	Odetola & Okanlawon, 2014
Mapped the effects of a provider job aid (mHealth application on the overall quality of ANC services and client satisfaction in Nigeria	E3	McNabb et al., 2015
Aimed to improve the literature base, in particular, relation to the Nigerian context	E4	McNabb et al., 2015

2.3.5 Discussion

This review of the existing academic literature sheds light on the current knowledge regarding digital health implementation. The three selected articles all originate from Nigeria, possibly reflecting limited evidence of digital health implementation in the country and, of course, the restriction of included papers to Nigeria and maternal and child healthcare. However, there might be existing health IT implementations that are not yet published.

Two relevant papers (Ebenso et al., 2018; Lee et al., 2016) that reviewed the effectiveness of digital health implementation for maternal and child healthcare in Nigeria were later removed because they were review protocol and systematic review, respectively, not primary research.

The predominant digital health intervention in the studies was mHealth, which indicates that mobile health is leading the way in digital transformation in the Nigerian health system and other LMICs (Mcnabb et al., 2015; Obasola et al., 2015). However, there was not much reported on the impacts of such a tool. Mobile health technologies are pervasive and portable with the ability to deliver efficient and personalised health. At the same, there are limitations to how mHealth can persistently manage health information. For example, mobile phones and applications are effective for patients who access their data wherever they are without concern about how and where the data is stored.

Conversely, EHRs are used by healthcare professionals (HCPs) to manage patient data during encounters and to do research in improving care delivery. These encounters usually involve different service points such as MCH, laboratory, consultation and pharmacy, and patient data are shared across these points, which require more resilient capabilities than mobile technologies can offer. Technologies like servers, databases and networking are needed to manage the complex interactions between HCPs, machines and patient records.

In total, 55 findings were extracted from the articles. These findings were classified using a simple logic model, including the five pathways of intervention, activities, outputs, outcomes, and impact. To ensure a tight focus, the scope of the review was explicitly limited to findings related to the effectiveness of digital health implementation, thus excluding the mediating factors of the digital health pathways.

This review is related to another systemic review (Baxter et al., 2014), which used the logic model to synthesise published literature but focused on describing complex pathways in referral management interventions.

2.3.6 Limitations

Having done this systematic review and based on reflections, perhaps a realist synthesis may have added further valuable insights. However, this review is not a literature

overview, but it considered implicit logic models from the selected studies, which are not miles away from the context-mechanism-outcome (CMO) configuration used in a realist analysis.

2.4 Critical assessment of knowledge gaps and anticipated contribution

Following the literature review, there is limited evidence on the:

- Actual implementation of electronic health records (EHR) in primary health centres (PHCs) in Sub-Saharan Africa (Odekunle et al., 2017).
- Sustainability of EHR implementation in developing and developed countries.
- Evaluation of existing EHR implementations.
- Benefits of interoperable EHR implementation in Nigeria.

The study made deliberate attempts in addressing the knowledge gaps above and anticipated the following contribution. The findings from the engagement with MCH/PHC stakeholders will produce a modified theory of change (ToC) in a context that has never been applied based on the evidence available from the literature review.

2.5 Chapter summary

The following are the summary of findings from the review of literature:

- The protocol for systematic review adopted the population, intervention, comparators, outcomes and study designs (PICOS) elements to identify the inclusion and exclusion criteria for the review.
- Five logic model pathways, namely interventions, activities, outputs, outcomes and impact were used as the conceptual framework to classify included studies.
- Three eligible studies were included for data extraction and were critically analysed.
- The logic model yielded 55 findings from the included studies through the pathways classification.
- The literature review spotlighted the limited evidence on actual EHR implementations in LMIC primary care as a knowledge gap among others. Based on the knowledge gaps, the anticipated contribution of this study is to produce a modified theory of change (ToC) for EHR implementation in an LMIC setting.

Chapter 3: Theory of Change

3.1 Overview

This chapter discusses the Theory of Change as the framework underpinning this study alongside other frameworks. [Section 3.2](#) introduces the Theory of Change with its origins and underlying factors. [Section 3.3](#) compares ToC with selected frameworks in health informatics. [Section 3.4](#) summarises the chapter.

3.2 Introduction to Theory of Change (ToC)

3.2.1 Origins of Theory of Change

The origins of ToC can be traced to Weiss, Chen and Rossi, who did extensive work in the area of theory-driven and theory-based evaluation (TBE) (Chen & Rossi, 1983; Weiss, 1995). In particular, Weiss popularised the term and modestly defined a ‘theory of change’ as a theory of how and why an initiative will work (Weiss, 1995). This definition seems simplistic, yet it is foundational. ToC has evolved over the years, considering the ever-changing complexities in international development programmes. This study adopts the definition of ToC by the UK’s Department for International Development (DFID) as *“an outcomes-based approach which applies critical thinking to the design, implementation and evaluation of initiatives and programmes intended to support change in their contexts”* (Vogel, 2012). This definition relates to this feasibility study as the study aims to bring about change by introducing EHR implementation in a primary healthcare context. Figure 10 illustrates a typical ToC diagram with a description of each component.

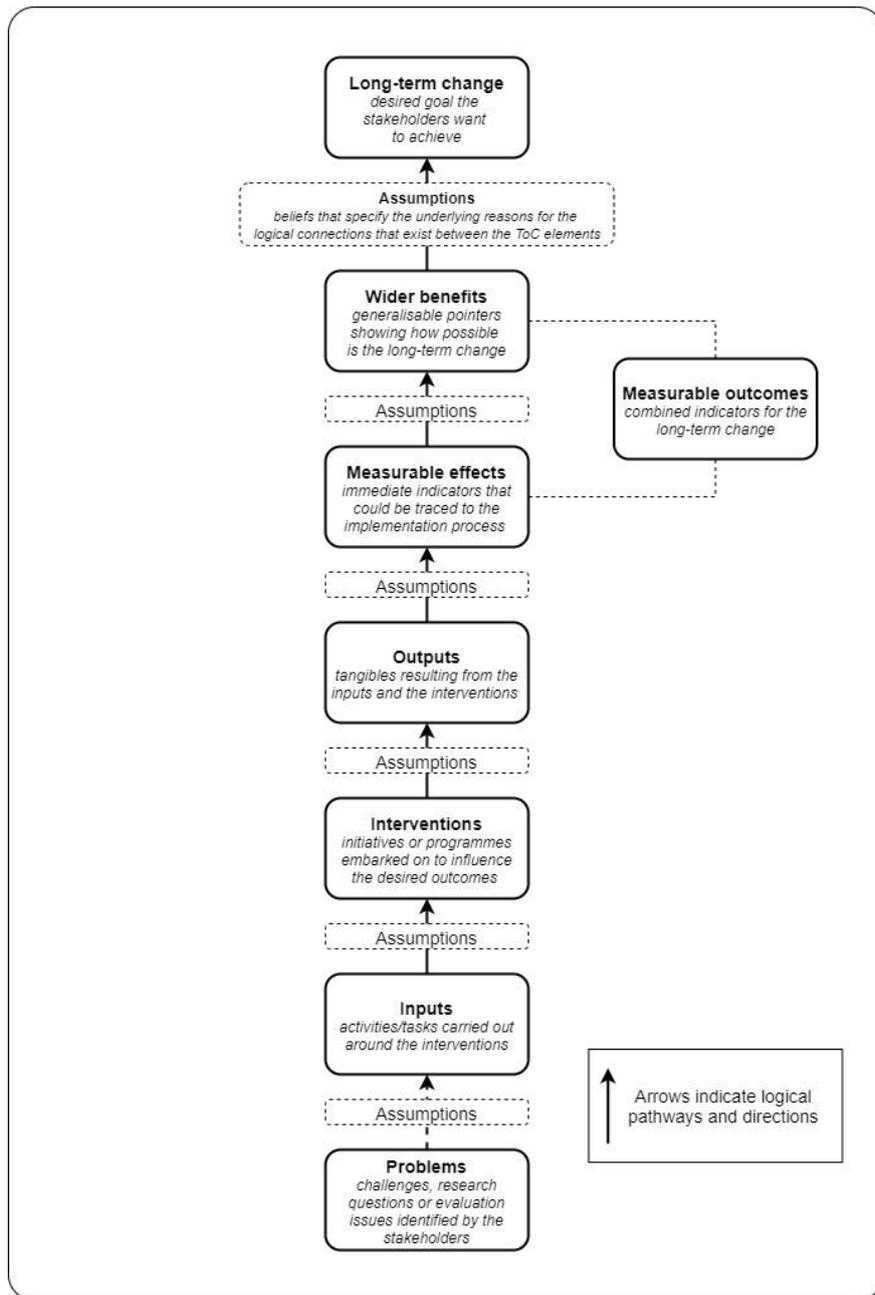


Figure 10: A typical Theory of Change diagram with components and descriptions

3.2.2 Theory of Change: a process and a product

ToC is both a *process* and a *product* (Scott, 2016). The ToC process articulates the mechanisms of change. The process begins when stakeholders set out a long-term goal and go in a reverse direction to specify assumptions and identify preconditions to bring about the desired outcomes (Taplin, Clark, Collins, & Colby, 2013). Hence, the process leads to the product (ToC map), which is usually developed in versions before, during

and after programme implementations. Despite not having a single way of designing ToCs, good quality ToCs should entail specific components such as long-term goals, assumptions, interventions, measurable outcomes, inputs and outputs (Connell & Kubisch, 1998). For a ToC to be deemed effective for any programme or study like this EHR implementation, it should fulfil these three criteria: *plausible*, *doable* and *testable* (Weiss, 1997). The combination of assumptions from practitioners' experiences, evidence from literature, findings from previous implementations and programme designer's implicit logic substantiates the credibility of a ToC. In particular, articulating explicit assumptions about the feasibility of the EHR implementation helps to expose, test and correct the programme design logic. The assumptions are like theories, which guide each ToC component and their inter-relationships, and there is no one-size-fits-all set of assumptions. They vary from context to context and intervention to intervention (Nkwake, 2020; Weiss, 1995). Based on the specified assumptions, the activities carried out around the intervention will result in outputs, which in turn result in indicators that can be measured to gain the confidence of the relevant stakeholders – government, funders and non-profits, healthcare workers and ultimately patients (Connell & Kubisch, 1998).

3.2.3 Theory of Change: a theory or an approach?

Certain authors have argued that theory-based evaluation (TBE) approaches such as ToC is more a methodology than a theory. This is because ToC uses different research methods (e.g. RCTs, interviews and workshops) for its development (Breuer, Lee, De Silva, & Lund, 2016; De Silva et al., 2014). ToC provides a structure for different techniques to plug in and guides the process of the project in achieving its goals. Weiss argues that ToC is an approach and a theory because it is built on assumptions/beliefs, preconditions, inputs, outputs and outcomes, which influence the way people behave (Weiss, 1997). However, the assumptions are subjective and difficult to test because they are based on people's perceptions of reality. Nonetheless, other ToC elements such as outputs and intermediate outcomes can be measured for effectiveness or impact.

Section 4.3.3 provides a detailed methodological description, Chapter 5 demonstrates the findings, and Section 6.2 discusses the practical applications of ToC.

3.3 ToC and other evaluation frameworks

There are numerous evaluation frameworks used in health informatics, such as the logical framework (logframe), DeLone and McLean (D&M) information systems (IS) success model and examples in the WHO digital health monitoring and evaluation guide (DeLone & McLean, 2003; Uvhagen, Hasson, Hansson, & Von Knorring, 2019; World Health Organization, 2016). These frameworks have a broad purpose of assessing the maturity of an intervention over time but focus on specific criteria or dimensions. For instance, logframes involve designing, monitoring, and evaluating inputs, activities, outputs, and outcomes logically to achieve desired results (Goeschel, Weiss, & Pronovost, 2012). While logframes are linear and easier to model with less difficulty, the ToC approach is organic and handles more complexities (De Silva et al., 2014). The D&M IS success model measures the “complex-dependent variable” in IS studies (DeLone & McLean, 2003). This model is widely used to assess the interrelationship between critical evaluation dimensions of IT interventions, including information quality, system quality, service quality, system use/usage intentions, user satisfaction and net system benefits (Nguyen et al., 2014; Ojo, 2017). In a developing country context, D&M IS success model has been validated by studying electronic hospital information systems in five Nigerian teaching hospitals (Ojo, 2017). The WHO digital health guide is not a single framework. It examines several evaluation frameworks and illustrates how they could be practically employed to support digital health implementation in various contexts (World Health Organization, 2016). Having considered better-known evaluation frameworks, it is worth noting that the ToC scope goes beyond evaluation and covers planning, co-design, stakeholder engagement and the linkage of causal pathways to individual outcomes.

3.4 Chapter summary

This chapter has shed light on the Theory of Change and its relevance as follows:

- ToC is an approach that has its roots in theory-driven and theory-based evaluation.
- The ToC approach is simply how and why an initiative will work.
- ToC is both a process and a product. As a process, it has components with logical connections. As a product, maps are produced iteratively as a result of the process.
- Logframes, DeLone and McLean (D&M) information systems (IS) success model and examples in the WHO digital health monitoring and evaluation guide are better-known evaluation frameworks in health informatics, but the ToC scope goes beyond evaluation and covers planning, co-design, stakeholder engagement and the linkage of causal pathways to individual outcomes.

Chapter 4: Primary research methodology and design

4.1 Overview

Ideally, for most substantial and empirical research, there is the nature of reality and the understanding of 'how' the reality is achieved and evaluated. These represent the philosophical, theoretical and methodological foundations of such research. This chapter details the research process undertaken to investigate how the benefits of electronic health records (EHR) implementation could be realised in Nigeria. [Section 4.2](#) presents the philosophical underpinning guiding this research. The research design drew predominantly on the Theory of Change (ToC) and supplemented the ToC with certain success criteria ([Section 4.3](#)). [Section 4.4](#) describes the context of the pilot EHR implementation for this study. [Section 4.5](#) highlights the primary data collection/selection and analysis methods. The remaining sections describe the EHR system selection and evaluation process ([4.6](#)) and the ethical considerations ([4.7](#)).

4.2 Philosophical perspective

There are varying schools of thought about the extent to which the philosophical perspective of a researcher is or is not an important consideration. Some research projects take this perspective as necessary, but others regard it as less important, instead go straight into applying methods in the real world. The former claims a theoretical standpoint for their research, while the latter holds a pragmatist view. Most research, especially in information systems (IS) and computing, would typically have underlying philosophical paradigms depending on their ontology and epistemology.

A paradigm is a way of thinking or a set of shared conceptions about a certain facet of the world (Oates, 2006). Ontology relates to the shared assumptions or constructions about the real world in different communities. Epistemology entails the ways or how these communities get knowledge about reality or "*a broad and high-level outline of the reasoning process by which a school of thought performs its empirical and logical work*" (Lee, 2004, p. 5; Oates, 2006).

How the impact of assumptions is measured will determine which philosophical paradigm any IS research falls under. For example, the potential impact of this research study includes constructs such as the number of health staff trained and empowered by the use of the EHR system and the efficiency gains achieved in managing health records electronically. One could measure these constructs tangibly. However, constructs such as happiness, sadness, or frustration experienced using the EHR system might be challenging to measure tangibly. Natural science researchers would generally argue that constructs are measurable and countable when they relate to facts and figures, while human constructs of reality cannot be measured. Conversely, social scientists contend that some human experiences can be measured as human concepts.

In communities such as engineering, the philosophical perspective gears towards ontological realism or ontology agnostic/neutral. The ontological realist claims that reality exists independent of the human mind and experience (objective reality without contextual factors). In contrast, the ontology agnostic/neutral sees facts as neither objective nor subjective, i.e. no attention is paid to any philosophical perspective (Jenkins, 2010).

Although some IS researchers lean towards objectivity (e.g. facts and figures) in constructing reality as in natural science, people's construction of reality or idealism indicated the epistemology for this research. Nonetheless, there is epistemological flexibility within the ontological boundaries of this study (Levers, 2013).

4.2.1 Categories of philosophical paradigms

Philosophical paradigms can be broadly categorised into *positivist*, *interpretivist* and *pragmatic research*.

4.2.1.1 Positivist paradigm

In a positivist worldview, there is the assumption that the world is objective rather than subjective. This perspective is popular in health informatics and information systems research (Oates, 2006; Orlikowski & Baroudi, 1991). It bases knowledge on science,

theoretical laws, and empirical method rather than guesswork or thought alone (Hughes & Sharrock, 2016). However, the perspective is not appropriate to studying the social world, i.e. people, organisations, and group structures. It is a drawback to IS research because “*the design and use of information technology in organisations, in particular, is intrinsically embedded in social contexts, marked by time, locale, politics and culture. Neglecting these influences may reveal an incomplete picture of information systems phenomena*” (Orlikowski & Baroudi, 1991, p. 12).

4.2.1.2 Interpretive paradigm

The interpretive paradigm addresses some of the drawbacks of positivism with the assumption that the social world is not predictable. Instead, it is socially constructed, formed and strengthened by people’s actions and interactions (Orlikowski & Baroudi, 1991). This perspective, therefore, underlines the importance of subjective meanings or realities. Oates (2006, p. 292) defines interpretive IS research as “*concerned with understanding the social context of an IS, i.e. the social processes by which it is developed and construed by people and through which it influences and is influenced by its social setting*”. Hence, the goal of interpretive studies is to identify, explore and explain how all the factors in a particular setting are related and interdependent. This goal is opposed to reductionism used in positivistic research (Oates, 2006). The interpretive paradigm aims to produce deep insights into information system phenomena in its natural setting (Klein & Myers, 1999; Orlikowski & Baroudi, 1991). Hence, this study considered this perspective to understand the use and effectiveness of digital health for maternal and child healthcare service delivery.

4.2.1.3 Pragmatic paradigm

From a pragmatic perspective, a study can integrate more than one paradigm. For example, a study might start with positivist ontologies but will test its assumptions with interpretivist ontologies. Hence, a different set of methodologies and methods will be used in such a study (Weaver, 2018). Again, the study could adopt a scientific approach

in developing a technological application that does not involve humans but might use quantitative or qualitative methods to test the real-world impact.

4.2.2 Philosophical perspective for this research

This research falls within the interpretivist tradition because it seeks to understand the social processes by which a digital health system is developed and construed by people. Through this understanding, IS influences and is influenced by its social setting (Oates, 2006). This paradigm was considered appropriate for investigating the social processes of developing EHR systems and their use in the primary care setting in Nigeria. The research methods employed were mainly qualitative and were determined by the research questions, which required in-depth applications with practical significance to the context of the investigation.

4.3 Research outline

4.3.1 Research design

The study adopted the Theory of Change (ToC) approach as a methodological neutral approach that accommodated various methods: action research (implementation) and qualitative techniques in collecting and analysing data. The study collected primary data from the stakeholders in primary healthcare through directed interviews ([Section 4.5.1](#)) and a workshop ([Section 4.5.3](#)) because they give a rich and in-depth picture of the complexities of the EHR implementation in the primary care context. Furthermore, the ToC approach was supplemented with certain success criteria (Table 15 in [Section 4.3.4](#)) to ensure the evaluation rigour of the research findings. Table 13 gives a summary of the research design for this study.

4.3.2 Data description

The main kind of data collected from this study is textual data based on the research design. *Textual data* included transcribed speech from participants during interviews and the workshop. However, some *numerical data* were collected, including the number

of registered patients entered into the EHR system, the number of electronic forms (for antenatal, vaccination, visit notes and vitals) completed over time, and the system evaluation/user survey.

4.3.3 Theory of Change approach

The Theory of Change (ToC) approach guided the pilot study conducted in Festac Primary Health Centre (PHC). It helped in identifying the preconditions needed to realise the long-term goal of the study. The ToC approach works backwards from long-term goals to the inputs and mediating components required to achieve those goals (De Silva et al., 2014; Vogel, 2012). Due to the complex nature of an EHR implementation, the study iteratively developed and revised ToC maps (Figures 11, 12, 18) with the relevant components. The ToC maps illustrated components such as the *problems* the research was trying to solve, the *key stakeholders*, *assumptions*, *inputs*, *interventions*, *outputs*, *measurable effects and wider benefits* of the implementation to realise the *long-term change* (Breuer et al., 2016).

Table 13: Overview of research design

Research question (RQ)	Method/Approach	Description	Rationale
RQ₁ – How can EHR implementation effectively benefit the delivery of maternal and child health in Nigeria?	Systematic review and protocol (sections 2.2 & 2.3) Theory of Change	The action research included the following: Conduct a readiness assessment, initial workflow analysis and risk analysis by email/skype consultation with the management of the primary healthcare centre. From the analysis, create an outline benefits network and a first draft of the theory of change map. Order IT equipment and software to be in place when the implementer arrives at the study site. Travel to Lagos State and install the IT equipment, including PCs, network, open-source (free) EHR and ancillary software. Update the initial workflow analysis and risk analysis with staff on the ground and use this information to optimise the EHR software configuration. Agree on a detailed EHR implementation and workflow plan with local staff and managers. Provide training and support the operational implementation. Concurrently evaluate the EHR impact and user perceptions through semi-structured qualitative interviews.	The systematic review (SR) and its protocol were necessary to identify existing evidence and to establish the gaps in the literature, which formed the basis for the contributions of this study and the theory of change. Theory of Change (ToC) effectively engaged practitioners and decision makers when designing, implementing and evaluating the EHR in the local context. In particular, ToC was used as a programmatic design and evaluation tool to reinforce the SR evidence and the impact of the EHR system for the domain of maternal and child healthcare (MCH) in Festac PHC (Craig et al., 2013; De Silva et al., 2014). This approach produced comprehensive evidence-based findings, which could be helpful for funders, policymakers, and implementers to make digital health implementation choices. Furthermore, ToC facilitated the adoption of qualitative methods such as interviews, a workshop and document analysis to gain deeper insights into the phenomenon being studied.
RQ₂ – What are the sustainable factors of digital health implementation for maternal and child healthcare, learning from experiences in developing and developed nations?	Theory of Change Directed review	The EHR implementation in Festac PHC, Lagos, Nigeria, was evaluated using the established success criteria (Deriel et al., 2018; Fritz, Tilahun, & Dugas, 2015). Lessons were learnt from the implementation and further informed by existing EHR literature and implementation reports.	Theory of Change (as explained above) The review of existing EHR studies was useful because it shed light and provided evidence-based backing for the practical implementation.

RQ3 – What are the priorities, preconditions and barriers to implementing an interoperable EHR in Nigeria?

Workshop

The researcher facilitated a conference workshop where global health informatics experts discussed questions to structure deliberations on priorities, pre-conditions and barriers to an interoperable EHR implementation.

The workshop was a powerful research method that enabled expert participants' engagement, interaction, and collaboration in exploring the subject in question. The willingness of the participants to provide rich information about the interoperability topic was expressed because the participants felt valued and heard.

4.3.3.1 ToC components definitions

In the context of this study, the ToC components have the following definitions (Table 14).

Table 14: Theory of Change components and their definitions

Component	Definition
<i>Long-term change</i>	The desired goal the stakeholders want to achieve.
<i>Problems</i>	The challenges facing the current paper-based health records workflow as highlighted by the stakeholders.
<i>Stakeholders</i>	The people directly or indirectly involved or affected by the success or failure of the EHR implementation.
<i>Assumptions</i>	The beliefs that specify the underlying reasons for the logical connections that exist between the ToC elements. These beliefs are usually informed by research evidence, clinical practice and the environment in which the change is taking place.
<i>Inputs</i>	The activities/tasks carried out around the intervention.
<i>Interventions</i>	The initiatives or programmes embarked on to influence the desired outcomes; in this study, the EHR implementation and sustainability arrangements.
<i>Outputs</i>	The tangibles resulting from the inputs and the intervention.
<i>Measurable effects</i>	The immediate indicators that could be traced to the implementation process and are readily usable for evaluation. These measures can be quantitative or qualitative.
<i>Wider benefits</i>	The generalisable pointers that could guide the stakeholders as to how possible is the long-term change.

4.3.3.2 ToC development

The research developed the first ToC map (Figure 11 in [Section 5.3](#)) based on evidence from literature, consultation with the local health information manager and findings from previous EHR implementations. The health practitioners and decision-makers in Festac PHC were engaged in designing, implementing, and evaluating the EHR system. In particular, the health practitioners in Festac PHC joined in developing the ToC versions, especially providing practical experiences that shaped the ‘theories’ underpinning the ToCs. This approach facilitated realistic interactions with the stakeholders and gave a proper understanding of the local context where the study was conducted (Cordeiro & Soares, 2018; Thobias & Kiwanuka, 2018).

Furthermore, the study developed a revised ToC map (Figure 12 in [Section 5.4](#)) to accommodate changes during and after the EHR implementation. It helped recognise

that implementers should pay attention to sociotechnical issues, especially the interplay between patients' realities, HCPs' mental models and how these influence the EHR design and are represented within the system (Scott & Briggs, 2010; Smith & Koppel, 2014).

A generic version of the ToC map (Figure 18 in [Section 5.10](#)) was developed to reflect a holistic framework as a toolkit for relevant stakeholders who want to embark on this kind of intervention in similar contexts beyond Lagos, Nigeria. The stakeholders can adapt it for EHR implementations in primary care settings but pay close attention to inherent characteristics in those environments. Despite the nuances in different contexts, the process and steps in the ToC map are not to be ignored. Chen and Rossi stressed the importance of giving adequate attention to understanding the implementation process and not being concerned whether the initiative has yielded excellent results (Chen & Rossi, 1983).

4.3.4 Success factors/criteria

The ToC approach is not immune to problems when used as an evaluation tool. Theorising issues, measurement, testing, and interpretation are not unusual (Weiss, 1995). To evaluate the maturity of the implementation, the study adapted the success criteria used in Deriel et al. (2018) and Fritz et al. (2015) to supplement the ToC approach. Table 15 outlines the categories considered for the success criteria of the implementation and provided definitions for each category.

Table 15: Categories for success criteria and their definitions for EHR implementation (adapted from (Deriel et al., 2018; Fritz et al., 2015))

Categories	Definitions
Ethical	Regulatory and cultural issues such as health data security, privacy and confidentiality.
Political	Health policies and country-wide circumstances including health care infrastructure, characteristics, Ministries of Health, Primary Healthcare Boards.
Organisational	Managerial circumstances within the organisation itself including human resources/skilled staff/local buy-in, leadership and governance, project management and commitment to implementation, data use.
Financial	Resources (including human and equipment) and funding.
Functionality	System features and functions, including modules, data handling, forms and reports.
Technical	Infrastructure, software architecture, user interfaces, data standards, privacy/security.
Training	Skills training as well as computer literacy and educational background, user support.
Sustainability	Transition from external stakeholder to local management across all categories including financing.

4.4 Setting

4.4.1 Festac Primary Health Centre

The study was conducted in Festac Primary Health Centre (PHC), Lagos, Nigeria (see [Subsection 1.5.5](#) for rationale). In Festac PHC, patient information was written on paper and maintained in folders and health registers, posing confidentiality issues, missing records and inefficiencies. As of August 2019, Festac PHC served an estimated population of 27,273 residents and had 20 healthcare professionals. A research team funded by the Global Challenges Research Fund (GCRF) (UK Research and Innovation, 2021) through the University worked with Festac PHC management to conduct a feasibility study for EHR implementation in the health facility. The health facility comprised six service departments (or service points), including the mother and child centre, health records, consultation, general outpatient, laboratory and pharmacy. The

mother and child centre consists of midwives who deliver maternal and child health services and keep patient records through registers such as ANC, immunisation, delivery and family planning. The *health records unit* has health information officers (HIOs) that collect and maintain patient information with the help of registers, folders and filing cabinets. The *consultation unit* consists of doctors (medical officers) who diagnose patients and keep patients' clinical notes. The *general outpatient department* (GOPD) comprises community health workers (nurses) who observe and record patients' vital signs. The *laboratory unit* of the PHC has a laboratory scientist and technicians who run test and maintain test data (specimen source, request and results) of patients, which helps diagnostic decisions of doctors and midwives. The *pharmacy department* consists of a pharmacist and pharmacy technicians who order, maintain and dispense medicines to patients. In total, the programme involved 20 healthcare professionals (3 doctors, 5 midwives and nurses, 2 community health officers, 1 pharmacist, 1 medical laboratory technician, 6 health records officers and 2 monitoring and evaluation officers) who were directly involved with patient data.

The study commenced by conducting a remote scoping study that included readiness assessment, initial workflow analysis and risk analysis via email/Skype consultation with the management team of the Festac PHC.

4.4.2 Stakeholder meetings

The study organised stakeholder meetings, which involved heads of department and the EHR champions in the PHC at the start and during the implementation process. Each stakeholder discussed the issues of the existing paper-based health system, their expectations and experiences of the new EHR system.

4.5 Data collection and analysis

4.5.1 Interviews

During the implementation study, semi-structured interviews were conducted with primary healthcare professionals before implementing EMR in Festac PHC.

Interviewees were identified by a purposive sampling method. Each interviewee was selected as a health professional working in Festac PHC, who might be willing to discuss their perspectives on introducing the EHR to their health facility. The participants completed a consent form (see Appendix 4). The data collection process ceased when the saturation of concepts was reached.

The semi-structured interview guide (see Appendix 5) included an average of 15 questions for three categories of healthcare staff (leadership, guiding and frontline teams) and focused on six main topics: goals and expectations of the EMR; skills and resources required for the project to succeed; leadership and communication styles; steps taken to prepare for the EMR; critical challenges to the implementation; and the desired impact of the EMR to the health centre. Interviews were conducted face to face and lasted approximately 30 minutes. All interviews were audio-recorded and transcribed verbatim.

4.5.2 The workshop process

A workshop for health informatics experts was held at the MedInfo 2019 conference, Lyon, France. The goals of the workshop were to (1) highlight the building blocks and functional requirements for EMR architectures for Nigeria and other LMICs; and to (2) discuss the priorities, preconditions, capabilities and barriers to implementing an interoperable EMR for MCH.

4.5.2.1 Discussion questions

The following questions were presented and discussed by the experts.

1. What are the priorities or drivers for actual EMR implementation? What can we learn from HICs and the few LMICs that are leading in this respect?
2. What are the preconditions for the envisioned EMR implementation, and how can they be met? (Examples: funding, infrastructure, the culture of quality and evidence-based thinking, adoption by stakeholders.)

3. What are the required/expected capabilities of the future EMR? What timescales and functional priorities are appropriate?
4. How can the EMR deployment become sustainable?

4.5.2.2 Workshop structure

The duration of the workshop was 90 minutes:

- A) 30 min. Introduction to EHR in developing countries. EHR implementation findings from Nigeria were presented.
- B) 30 min. Group work discussion on the questions.
- C) 30 min. Feedback and general discussion.

The group work discussion was recorded and transcribed.

4.5.2.3 Attendees/Experts

The experts who attended the workshop comprise (with some overlapping roles):

- Academic researchers with an interest in global health informatics (10).
- Policy makers responsible for health informatics programme planning and evaluation (3).
- Practitioners working in the aspects of public and global health especially maternal and child health (8).

The workshop collected key points from the attendees/experts, which were expanded with literature. The workshop's analysis and the affiliated institutions of the attendees can be found in [Section 5.8](#).

4.5.3 Document analysis

This study used qualitative document analysis to complement other qualitative research methods – interviews and the workshop for triangulation. Document analysis was described as “a systematic procedure for reviewing or evaluating documents – both

printed and electronic material" (Bowen, 2009). The review process entailed selecting, interpreting, and evaluating data from government and non-governmental reports, strategic health development plans, statutory documents, technical papers, and case studies related to the study's aim. The documents were purposefully selected throughout the study to gain a contextual understanding of digital health implementations.

4.5.4 Qualitative data analysis

The interview data were analysed qualitatively using thematic analysis by exploring themes or patterns across data sets. The Framework method (Gale, Heath, Cameron, Rashid, & Redwood, 2013) was used to guide the coding process of the directed interview transcripts. The Framework Method is an analysis method that belongs to the family of thematic analysis or qualitative content analysis. It identifies commonalities and differences in qualitative data before focusing on relationships between different parts of the data, thereby drawing descriptive and/or explanatory conclusions clustered around themes (Gale et al., 2013). Atlas.ti (version 7.1.4) was used to support the analysis of the interview data (ATLAS.ti, 2020). The detailed analysis can be found in [Section 5.5](#).

The selected documents were analysed informally to understand the policy environment and the context of digital health implementation (Bowen, 2009). The selected documents were characterised based on their sources, type, themes, data analysed, and location in the study. The findings are detailed in [Section 5.9](#).

4.6 EHR system selection and evaluation

4.6.1 OpenMRS

OpenMRS is an EHR software built for low-resource settings to improve healthcare delivery with the help of a global community that support the software (OpenMRS, 2016). Open Medical Records System (OpenMRS) was the EHR application selected for the pilot implementation because it is open-source and therefore freely available, which fits into the funding realities of LMICs, including Nigeria. OpenMRS codes can be

modified and tailored to the needs of the particular context it is being used. It is an enterprise platform with flexible modules that have matured over time and implemented in similar settings with a vibrant online community of developers and implementers (Muinga et al., 2018; Purkayastha, Allam, Maity, & Gichoya, 2019). Existing OpenMRS modules were adopted to facilitate the identified use cases such as patient registration, outpatient clinic, laboratory and mother and child clinic to manage clinical workflows.

4.6.2 System evaluation

The study conducted a user survey during the implementation to obtain feedback on the usage of the EHR system from the users (healthcare professionals). The goal of the purposive survey was to evaluate the usability of the newly implemented system. The survey obtained the agreement of the selected users about the following statements using a 5-point Likert scale (*Strongly Agree* | *Agree* | *Neutral* | *Disagree* | *Strongly Disagree*) (Likert, 1932):

1. EMR has increased overall efficiency
2. Computerised alerts and reminders are annoying
3. Our patients are OK with our use of EMR
4. EMR improves my personal productivity
5. EMR is difficult to use
6. Use of EMR in front of patients is depersonalising
7. EMR is not as accurate or complete as paper records
8. EMR improves quality and patient safety
9. A first step toward a successful EMR is addressing workflow and process changes
10. We are in an age where we must exchange data electronically with others. EMR helps us do this
11. Health care is too complex anymore without access to clinical decision support provided by EMR
12. EMR are not as secure as paper records

13. EMR can have unintended consequences if we don't apply professional judgment in its use

Also, the survey asked the users to rate the quality of the following EHR implementation aspects using a 5-point Likert scale (*Worse than Expected* | *Poor* | *Acceptable* | *Good* | *Better than Expected*) (Likert, 1932):

- a. Training
- b. Response time
- c. Dependability
- d. Technical support
- e. Ease of use

The system evaluation showed how well the EHR was meeting the needs of the healthcare professionals. The results were compared with the initial readiness assessment data as a benchmark and used to identify areas needing improvement (see [Section 5.6.4](#) for summary results).

4.7 Ethical considerations

This study obtained an ethical review, resulting in a favourable opinion from the Faculty Ethics Committee (Appendix 6). Participation in the study was voluntary, and participants were free to withdraw at any time without giving any reason. The participants provided written consent by completing a participant consent form. The security, privacy and confidentiality of patient records were considered at the inception of the study. The paper health records were kept and locked in a card room at the PHC. Although the reception is positioned close to the card room, at busy times, anyone could access the room with malicious intentions to cart away or damage the paper records. Hence, the EHR implementation took into account the secure access to the electronic records by creating user accounts for relevant clinicians, ensuring that only the users authorised by the head of departments could access the system (Adamu et al., 2020).

Chapter 5: Results

5.1 Overview

This chapter presents the analysis of the results from the investigation. The following section (5.2) narrates the journey of EHR implementation in Festac Primary Health Centre (PHC). The initial and revised theory of change (ToC) maps illustrate how the EHR implementation activities were realised in Festac Primary Health Centre (PHC) (Sections 5.3 and 5.4). Subsequently, Section 5.4 explains the long-term change and the identified preconditions from the ToC process. Section 5.5 demonstrates the qualitative findings that emerged from interviewing healthcare professionals in Festac PHC. Section 5.6 highlights the technical implementation and system evaluation of the EHR. Section 5.7 briefly unpacks the fundamentals of EHR interoperability. Section 5.8 expanded the workshop findings from the workshop held at the MedInfo 2019 conference. Findings from the document analysis were presented in Section 5.9. The study hypothesises that programme designers and relevant stakeholders can adapt the generic ToC map for EHR implementations in similar contexts (Section 5.10). The chapter then concludes with a high-level summary in Section 5.11.

5.2 EHR implementation in Festac PHC

The interest in conducting this research started with the awareness of the frustrating experiences of the paper health records system in low- and middle-income countries (LMIC) contexts. In particular, there was a quest to bring about some pragmatic change to these issues in a local primary care context as this is a key entry point to health services delivery for the most population in LMICs. After several consultations with personal contacts, this quest led to the awareness of health service delivery needs in Festac PHC, Lagos, Nigeria (see Subsection 1.5.5 for rationale). There was a funding opportunity within the University of Portsmouth (UoP) to undertake research targeted towards global challenges in LMICs, which relate to the goal of this study. A specific opportunity came up to apply for research funding provided by the Global Challenges Research Fund (GCRF) for international development projects. The funding application

was made to introduce EHR to Festac PHC, the application was successful, and the management approved the study (Appendix 7). Therefore, the research to conduct the EHR implementation commenced.

5.3 Initial Theory of Change

Following the definitions of the ToC components in [Subsection 4.3.3.1](#), Figure 11 shows all the components with their complex interactions. The desired *long-term change* component depicted the vision of the Festac PHC stakeholders based on the identified challenges. This component is important because it fostered cogent conversations among the stakeholders on the way forward and the preconditions for achieving the long-term goal. The *problems* component highlighted the specific inefficiencies experienced by Festac PHC and helped the stakeholders determine what kind of inputs will be required to address issues. The *inputs* element of the ToC map depicted the funding, organisational and technical activities carried out around the intervention. These activities were critical to the success of the EHR implementation and were catalysts to the *outputs* component. The *outputs, measurable effects* and *wider benefits* elements provided the measurable indicators, which were useful for the stakeholders in determining if the long-term change is achievable or not.

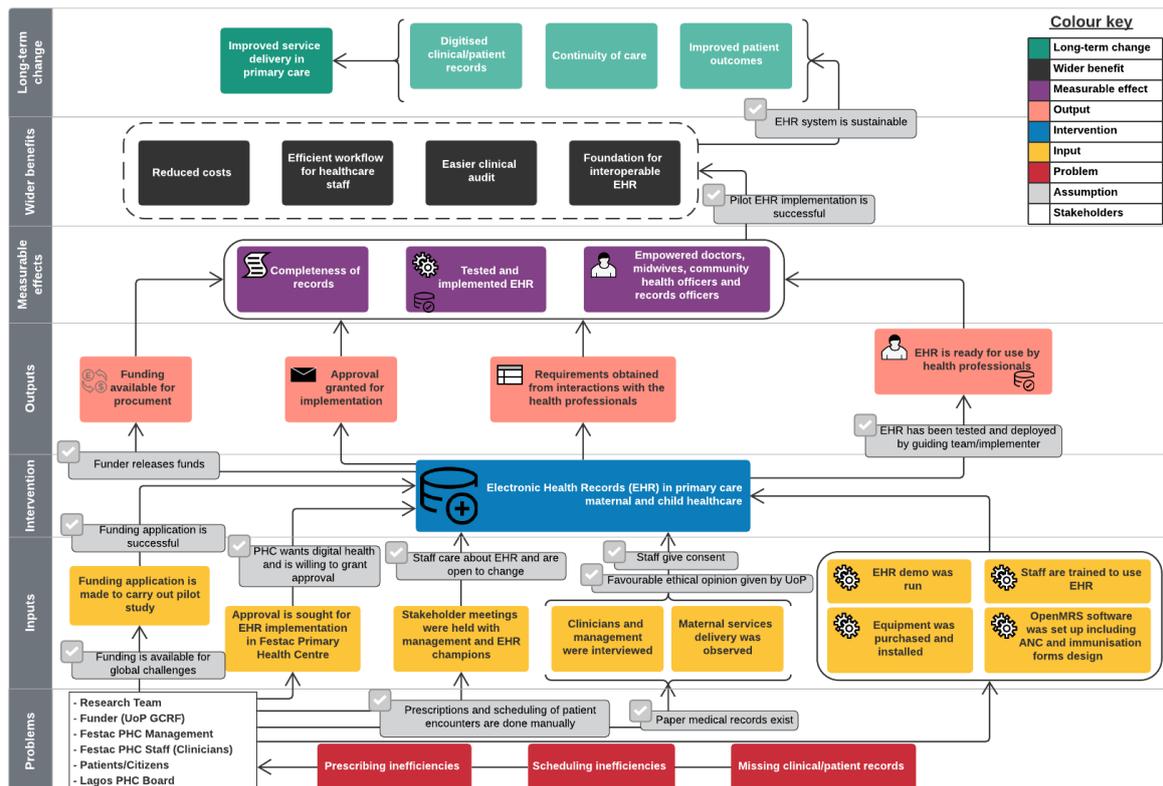


Figure 11: An initial version of the Theory of Change for the scheduled Electronic Health Records implementation in Festac PHC

The initial ToC map served as the basis for the actual implementation with preliminary assumptions emanating from prior knowledge of the research team, the literature of existing EHR implementations and practitioners' experiences. Initial assumptions included:

- 1) Paper medical records exist.
- 2) Prescriptions and scheduling of patient encounters are done manually.
- 3) Funding is available for global challenges.
- 4) Funding application is successful.
- 5) PHC wants digital health and is willing to grant approval.
- 6) Favourable ethical opinion is given by the University.
- 7) Funder releases funds for procurement.
- 8) Stakeholders care about EHR and are open to change.
- 9) Practitioners give consent to be interviewed and observed in the health facility.
- 10) EHR has been tested and deployed by the guiding team and implementer.
- 11) Pilot EHR implementation is successful.
- 12) EHR system is sustainable.

5.4 Revised Theory of Change

5.4.1 Revisions to the initial ToC

Following the actual EHR implementation, the initial ToC map (Figure 11) was revised (Figure 12) to reflect the real changes encountered during the pilot study. For example, priorities for the EHR system shifted from scheduling and prescription to antenatal care (ANC) and immunisation. As at the time of developing the initial ToC map, Festac PHC stakeholders identified the need for booking patient appointments and producing prescriptions electronically with the EHR. However, after the face-to-face stakeholder meeting at the health facility, the practitioners noted that e-forms for ANC and immunisation were their immediate needs for the EHR. Another change to the ToC revision was the shift in networking design from cloud to a local area network. This shift was due to connectivity problems and a lack of guarantee from the management in sustaining the internet subscription payment. This is the dominant approach with EHRs in LMICs, as a few smaller sites can guarantee good enough internet for cloud-based use, although certain countries do this well (Evans, 2016; Oza et al., 2017).

Also, the revised ToC (Figure 12) included the research workshop (MedInfo 2019, Lyon, France), where the EHR usage outcomes from the pilot study were presented. The workshop attracted advice from global health informatics experts. From the workshop, it was found that data models are key to realising effective communication exchange across digital health systems by adopting the appropriate interoperability standards for MCH with common examples, including Fast Healthcare Interoperability Resources (FHIR) (HL7, 2020) and OpenEHR (OpenEHR, 2020). Also, the drivers for an interoperable EHR differ between LMICs and high-income countries (HICs). For example, LMICs focus mainly on aggregate data from the health information system for disease control, population health monitoring and health policy and planning. Funders use these aggregate data to drive health financing and, in some cases, to fund EHR implementations. However, HICs pay more attention to the quality of care, continuity of care and precision medicine. In addition, adequate infrastructure and accountable funding were identified to be key preconditions needed for any sustainable EHR

implementation. In sum, toolkits are important in shaping EHR implementations for maternal and child healthcare services.

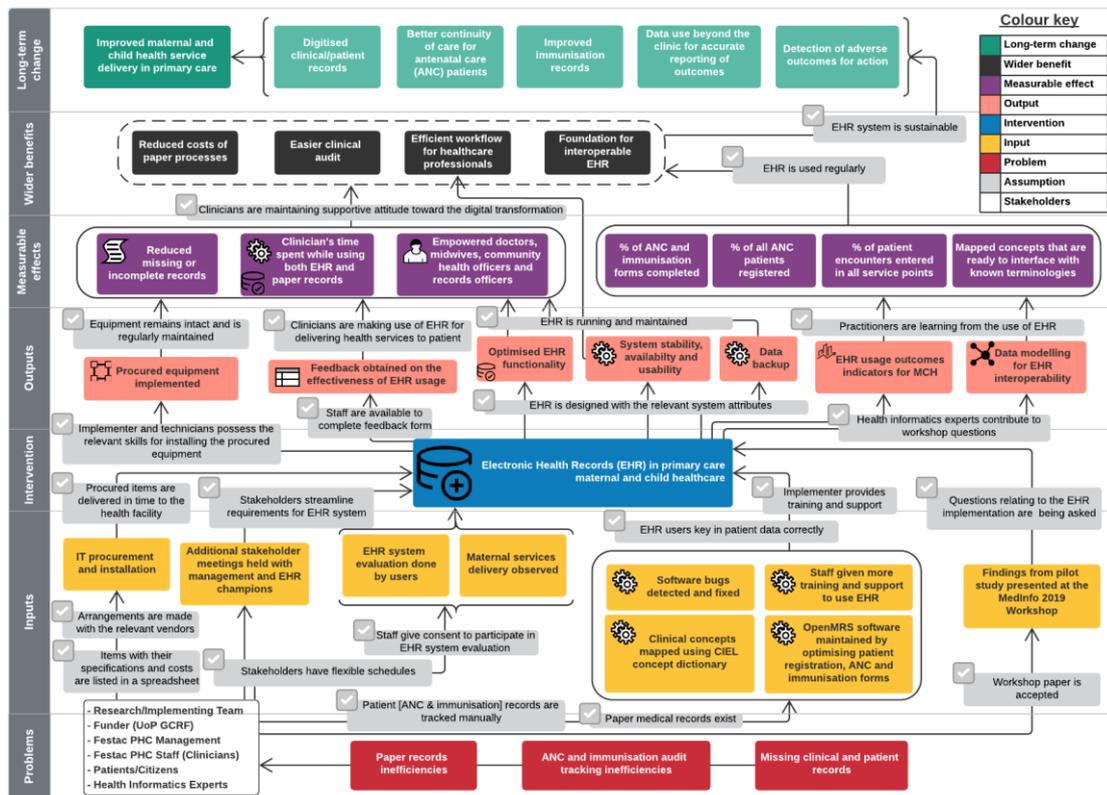


Figure 12: A revised version of the Theory of Change for Electronic Health Records implementation in Festac PHC, including a workshop at MedInfo Conference 2019.

5.4.2 Long-term change

The overarching goal for the EHR implementation study depicted in the initial ToC (Figure 11) was slightly modified to accommodate the assumptions from the practitioners during stakeholder meetings. Following the meetings, the long-term change was revised accordingly – to achieve an improved maternal and child health service delivery in primary care with the use of EHR (Figure 12).

5.4.3 Assumptions

While some assumptions stay the same, others were modified. Table 16 illustrates these assumptions and how they were generated.

Table 16: Assumptions and their sources

	Assumptions	Source
#1	ANC and immunisation records are tracked manually.	Practitioners
#2	Items with their specifications and costs are listed in a spreadsheet.	EHR implementation
#3	Arrangements are made with the relevant vendors.	Programme designer
#4	Procured items are delivered in time to the health facility.	EHR implementation
#5	Implementer and technicians possess the relevant skills for installing procured equipment.	Policymakers, Programme designer
#6	Stakeholders have flexible schedules.	Practitioners
#7	Staff give consent to participate in the EHR system evaluation.	Practitioners
#8	Stakeholders streamline requirements for EHR system.	Practitioners, Programme designer
#9	Implementer provides training and support.	Policymakers, Practitioners, Programme designer
#10	EHR users key in patient data correctly.	Practitioners, Programme designer
#11	Workshop paper is accepted.	Programme designer
#12	Questions relating to the EHR implementation are being asked by workshop participants.	Health informatics experts, Programme designer
#13	Health informatics experts contribute to workshop questions.	Health informatics experts, Programme designer
#14	Staff are available to complete a feedback form.	Practitioners
#15	EHR is designed with the relevant system attributes.	Practitioners, Programme designer
#16	Hardware equipment and EHR software remain intact and is maintained regularly.	Policymakers, Practitioners, Programme designer
#17	Clinicians are making use of EHR regularly for delivering health services to patients.	Practitioners, Policymakers
#18	Stakeholders are learning from EHR usage and data.	Policymakers, Practitioners, Programme designer
#19	Clinicians are maintaining supportive attitude towards digital transformation.	Policymakers, Practitioners, Programme designer

To improve MCH services to be established, it was assumed that the EHR system is sustainable. The EHR system needs to be used regularly to bring about the *broader benefits* of its implementation.

5.4.4 Wider benefits

Based on the assumption that the pilot EHR implementation is successful, there would be benefits accrued to Festac PHC. These benefits include reduced costs of paper processes, including expenses for stationery, efficient workflow for the healthcare staff, easier clinical audit of patient records and the readiness for an interoperable EHR system. The realisation of interoperability will enable an effective health information exchange as EHRs become widespread over time.

5.4.5 Measurable effects

It was anticipated that the availability of the EHR system alongside the surrounding outputs would result in the completeness of health records, which could be measured against the use of paper health records by the health practitioners. Other potentially measurable effects are the clinicians' time spent using both paper and EHR systems (Scott, Curley, Williams, Linehan, & Shaha, 2016). During the implementation, clinicians were found to spend more time using both paper and electronic systems simultaneously. Fourteen clinicians were enrolled to use EHR. Figures 13 and 14 show the EHR adoption rate and usage rate for the study phase 1 over five months (June 2019 – October 2019) from the system go-live. The number of registered patients and patient registration forms completed on the EHR system were 1790. ANC and immunisation encounter forms (n=198 and n=309) were completed. Vital signs (n=325) and visit notes (n=177) were entered into the EHR. The total number of encounter forms completed on the EHR was 2799. Longer-term success factors which are yet to be measured are funding sustainability and leadership realised, and health information exchanged achieved across EHR systems.

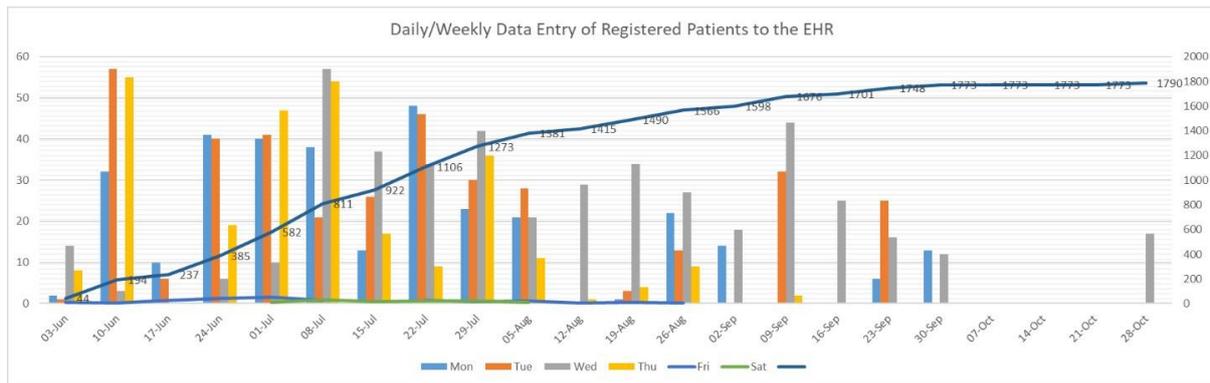


Figure 13: Daily/Weekly data entry of registered patients to the EHR system

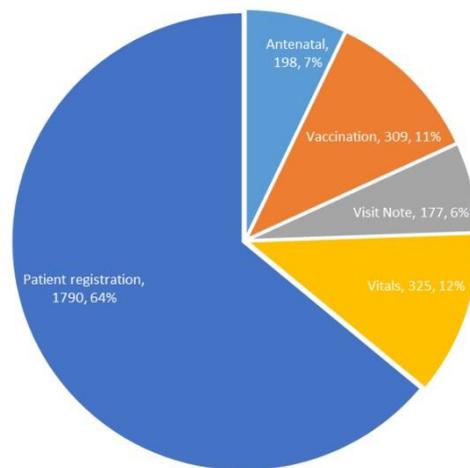


Figure 14: Electronic forms completed on the EHR system during encounters, %age of total entered

5.4.6 Outputs

The study received a letter of approval for the implementation from the local authority. This approval enabled the release of funds and the travel of the research team to the health facility. The funder released the funds to procure the IT equipment needed for the study. The interactions with the health practitioners made it possible to obtain the requirements to design and develop the intervention. Following the active inputs of various stakeholders, the EHR was ready for use by the health practitioners. Outputs in the revised ToC map were procured equipment, feedback from EHR usage, optimised EHR functionality, EHR usage outcomes indicators for MCH and data modelling for EHR interoperability. Other key outputs were the critical system attributes (such as system stability, availability and usability) and full and incremental data backup of patient records on the cloud. In the event of system damage, fire, flooding or any

unfortunate incidents, the PHC can restore the records from the backup. Cloud backup is getting more secure with more measures put in place by vendors and regulators.

5.4.7 Intervention

The main intervention ([Section 4.6](#)) for this study is the introduction of EHR in primary care maternal and child healthcare. Initially, problems were perceived based on explicit and implicit assumptions about paper medical records and that prescriptions and scheduling of patient encounters are done manually. After face-to-face stakeholder meetings on-site, the practitioners were unanimous that prescribing and scheduling inefficiencies were not the priority issues but paper records handling, ANC and immunisation tracking inefficiencies and missing patient records. These problems validated the introduction of the EHR intervention to Festac PHC.

5.4.8 Stakeholders

The stakeholders were the researcher, funder, Festac PHC management (local authority), primary healthcare board, healthcare practitioners, patients and health informatics experts. They carried out several activities at various stages of the study. Some informal contacts were made with the local primary care facility to understand their problems and the desired long-term outcomes. Existing studies were reviewed to have background knowledge of previous EHR implementations in similar contexts. Following the review, the initial version of the ToC map was developed as informed by the explicit assumptions from the practitioners and implicit assumptions from previous implementations.

5.5 Qualitative analysis

Following the methods described in [Section 4.5.2](#), this section presents how the qualitative data from the interview transcripts were analysed, using relevant quotations, conceptual codes, tables, diagrams and boxes. The analysed texts used in the data are related to the main research questions. Codes were created as concepts for the selected direct quotations, but similar codes were merged iteratively as the analysis progressed.

Following the iterations, 527 quotations were observed/extracted in the data, and 46 conceptual codes were assigned.

The conceptual codes were subsequently categorised into themes and subthemes. These categorisations were both derived inductively from the grounded codes and deductively from existing EMR implementation studies. Dr Philip Scott independently reviewed the qualitative coding analysis.

Semantic network diagrams were constructed to visually analyse the relationships between categories and codes based on commonalities and differences in the data. Consequently, descriptive and explanatory conclusions were drawn from the relationships between different parts of the data focusing on the themes (and subthemes). Figure 15 illustrates the symbols used in Atlas.ti diagrams.

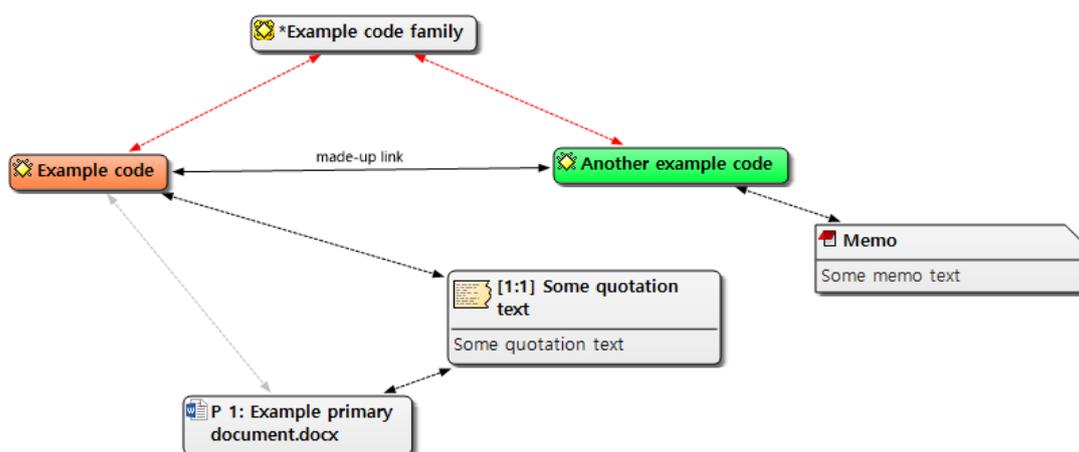


Figure 15: Atlas.ti 7 diagram notations

5.5.1 Description of participants

The participants (n=14) are healthcare professionals with diverse specialties, with slightly over 20% male and between 25 and 64. All the participants regularly engage in health service delivery and handle health records. Table 17 gives a demographic representation of interview participants.

Table 17: Participant demographics

Specialty	Sex	Age group	Participate regularly in health service delivery and health records
Public health nursing	Female	35-44	Yes
Medical records	Female	45-54	Yes
Health information management	Female	35-44	Yes
Health information management	Female	35-44	Yes
Community health	Female	25-34	Yes
Health information management	Male	25-34	Yes
Medical records	Female	35-44	Yes
Community health	Female	45-54	Yes
Public health nursing	Female	55-64	Yes
Midwifery	Female	45-54	Yes
Pharmacy	Male	45-54	Yes
Medical laboratory	Female	25-34	Yes
Health information management	Male	25-34	Yes
Public health nursing	Female	25-34	Yes

Three broad themes emerged from the analysis based on the interview questions and the quotations of the participants:

1. Readiness assessment of the health centre to adopt EMR;
2. Expectations for the EMR and its impact on health service delivery; and
3. Sustainability of the EMR implementation.

Table 18 presents the number of quotations from the participants across the three themes. What stands out in the table is that the interviewees have more to say about their readiness for the EMR implementation. At the same time, the thoughts of the nurses and health information managers were more prominent across all the themes.

Table 18: Total number of analysed quotations from interview participants across themes

Job roles/Themes	Expectations	Readiness	Sustainability	Total
Community Health Officers	42	39	6	87
Health Information Officers	53	78	9	140
Medical Laboratory Technician	16	12	1	29
Midwife	12	16	1	29
Monitoring and Evaluation Officers	36	70	2	108
Nurses	46	94	6	146
Pharmacist	9	14	3	26
Total quotations	214	323	28	565

A selection of illustrative and relevant free-text comments is placed in a shaded panel beneath. The code following each quoted comment denotes the participant ID (e.g. P2 = Participant #2). Each shaded panel is followed with a brief reflective commentary of what the quotations mean in the context of EHR implementation in Nigeria.

5.5.2 Theme 1 – Readiness assessment of the health centre to adopt EMR

The participants shared their perspectives on things to be in place to prepare for the EMR implementation. One participant remarked on the importance of conducting a situation analysis, highlighting the need for a readiness assessment.

Conduct a situation analysis like the way you've come now we find out what is first of all obtainable. You explain to them and then introduce the materials on what they are going to need such as computers, solar energy, because there is no steady supply of electricity. The solar power that will help with the CPU, the laptop you said it's going to stay for like four hours. P5

This view (“Conduct a situation analysis like the way you've come now we find out what is first of all obtainable” – P5) is typical of any EMR implementation where the project or implementing team conducts a readiness assessment of the health organisation to analyse their needs before commencing implementation.

From the analysis, participants' viewpoints were further broken down into subthemes representing key areas of readiness assessment, namely *organisational culture, management and leadership, operational and technical* (Figure 16).

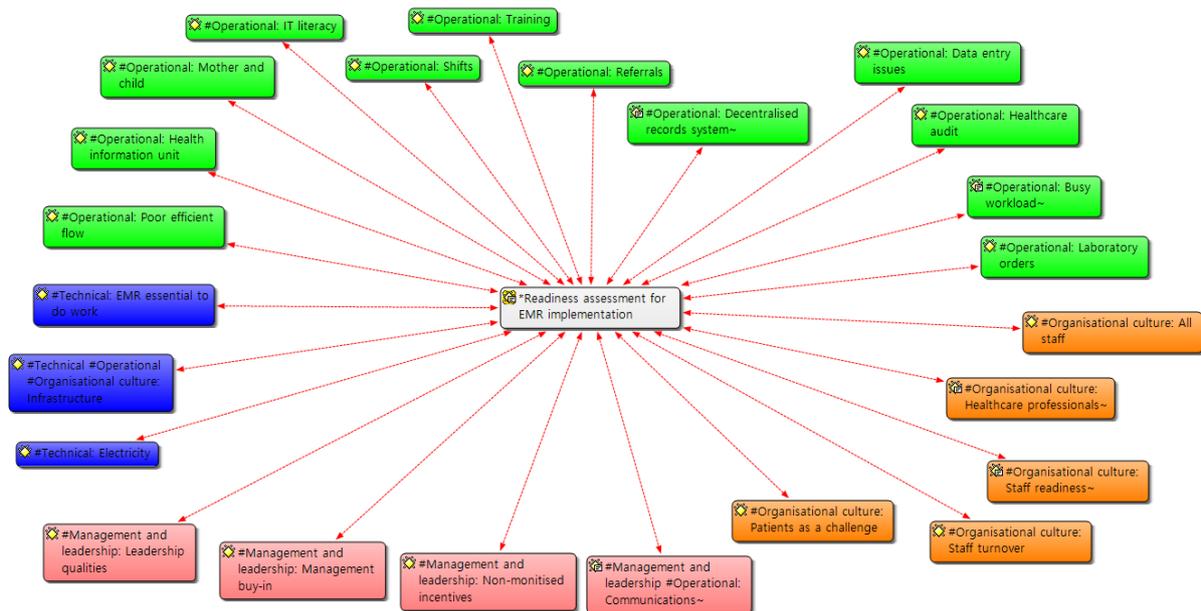


Figure 16: Overview of codes for EMR readiness assessment subthemes

Subtheme 1.1 – Organisational culture

This subtheme relates to the organisational perception of the EMR implementation in terms of staff and patient involvement.

Healthcare professionals

Healthcare professionals (HCPs) are key facilitators of the EMR implementation because they are the users of the system. A cross-section of interviewees made some points revolving around staff attitude, skill set, familiarity with EMR and fears that the EMR will take their jobs.

What we need actually...is human resources. Although some people believed that the introduction of computer system will reduce the workforce or the human capacity. My belief is that if anyone can use the system then that person is useful. P2

The skills we have are that of the health workers. The health workers here are professionals, they are trained. We have midwives, we have Public Health nurses, CHOs and we have BSc nurses. P9

The major skill here is the staff strength and then the attitude of the staff. P7

The key facilitators are us, because we are the ones that will be using the EMR. P1

The availability of the staff and readiness to do the work depending on how we are able to bring them in to understand the real thing that we want to achieve to make their work easier so that they will not be unnecessary anxious. P11

Many of them (staff) are computer literate and they know more about... and it seems we have many professionals there. They are familiar with electronic medical programmes probably when they were on the training and many of them had an encounter with workshops as regards to health information technology. They are capable. P14

We don't have fear for the workers. We do our work comfortably but you know when the boss is tough and hard...that can lead to anxiety the boss is around. There is nothing like that. P1

HCPs are instrumental to the success of the health system, especially in the aspect of using their expertise to support health IT implementations (“*The health workers here are professionals, they are trained. We have midwives, we have Public Health nurses, CHOs and we have BSc nurses*” – P9). Usually, IT professionals are known to develop technology solutions without a full grasp of the context or attempting co-design efforts with the HCPs. In the Nigerian health context, the HCPs are familiar with their manual health processes based on their training and experience (“*The availability of the staff and readiness to do the work depending on how we can bring them in to understand the real thing...*” – P11). Hence, it is vital to carry along the HCPs to understand their perceptions, observe their organisation culture and harness their expertise to design the EMR solution.

All staff

Although HCPs will have access to the EMR, they are not the only facilitators to the system's functioning. Some participants highlighted the crucial roles played by other non-HCPs.

All the staff are key because we are prepared, we are ready to make it work. P6

Everyone working within the health facility. Everyone. Everyone from the highest to the lowest, even the cleaner, everyone will be a key facilitator because if somebody is not happy and starts to destroy the cables. "This system that everyone is pressing, pressing, pressing, I will make sure it doesn't work". P2

If everybody is inline, the key thing is if we bring everybody along without any sense of discrimination or judging level, you understand, everything will work fine. if he sees the cables, he can easily call the attention of those responsible. So we, the humans, are the key facilitator, the human resources are the key facilitator to the implementation of EMR. P2

Although the HCPs are critical to the success of the EMR implementation, the administrative staff and other non-HCPs are also essential ("*All the staff are key because we are prepared, we are ready to make it work*" – P6). These non-HCPs are knowledgeable about the health facilities – they know where and how the equipment ought to be positioned so as not to affect the clinical processes ("*Everyone from the highest to the lowest, even the cleaner, everyone will be a key facilitator because if somebody is not happy and starts to destroy the cables*" – P2). Sometimes, these staff are not usually recognised as crucial in the Nigerian health system, perhaps due to their non-health or non-technical qualifications. Thus, EMR implementers must acknowledge them and leverage their knowledge of the health facility.

Staff readiness and acceptability

The participants expressed their eagerness to start using the EMR system for their work ("*They [frontline staff] are even ready for the EMR something to be in place. They want to use it, they just want to leave all this writing, writing, writing so we have the same plan for it*" – P1").

We have all accepted that it will help us to move forward. P3

They don't say: "no, I can't do this". They have a very positive attitude towards it [EMR]. P6

They (frontline staff) are even ready for the EMR something to be in place. They want to use it, they just want to leave all this writing, writing, writing so we have the same plan for it. P1

There should be no delay in fixing the computer systems, so that we can start working as soon as possible. P3

So far what I have been seeing is very encouraging most of the staff are really willing to work with this, they are anticipating it. P7

I have spoken to them (staff) about it. They are really very happy about it. Many are really looking forward to it and thankfully. Most of them are computer literate so it makes the job easy. P7

For any IT system to be introduced in a setting, the facility and users of such a system need to be willing to accept it (“*We have all accepted that it will help us to move forward*” – P3). Sometimes, the system implementation receives support or resistance because it changes the way people work. Since early 2000, the use of mobile phones in Nigeria has increased drastically, with mobile subscribers totalling 127.2 million in a population of 176.4 million as of 2014 (The World Bank, 2021). This widespread mobile technology usage has influenced the readiness and acceptability of digital health in the health context because the staff are somewhat aware of its benefits.

Other interviewees stressed the importance of individual willingness, learning and commitment to the EMR system.

We are ready to learn; we are ready to cooperate yes! P4

The key challenge has to do with the individual's commitment. Commitment is very key because we are people that have been used to doing things the same old way and we're quite comfortable with it because it looks easy, however it is very difficult in the long run. P10

If the staff are willing to work, there is nothing that won't be successful. If everyone is willing to make it work, I believe it is going to work. P7

I think I was part of the first set in the meeting (stakeholder meeting) that heard of the EMR, I got a lot from the meeting and from there I have been anticipating how this would work out. P7

I also took my time to read, take my time to search and gain more knowledge of the new things in the healthcare system and I think one of the new things now is EMR. P2

For the EMR system to become fully operational, the willingness and commitment of staff are essential (“Commitment is very key because we are people that have been used to doing things the same old way and we're quite comfortable with it because it looks easy; however, it is very difficult in the long run” – P10). Although change is not usually comfortable, the right attitude of staff towards the digital transformation can contribute to the system's effectiveness.

Staff turnover

Concerns were expressed amongst interviewees regarding the periodic transfer of healthcare staff to and from the health centre by the State Primary Healthcare Board.

What I am foreseeing is when these nurses we are training are posted out of this place and another set comes in, we may have a problem, a challenge of them learning the system at fresh. P9

You know they need to be trained on how to use it, training and retraining because you know as government officials, they transfer in and out, so when they are being retrained and trained. P11

A lot of us here are starting to use the EMR and getting used to it. As part of the government system, a staff can be posted out of Festac PHC tomorrow and they bring in another person who doesn't even have the knowledge of the EMR. So, that person comes in and before you try to change their orientation, adjust him or her to the system, that might take a lot of efforts. Also, if tomorrow, a new MOH comes in and does not buy into the whole thing, it might be a problem. P2

The challenge of staff movement (*“What I am foreseeing is when these nurses we are training are posted out of this place and another set comes in, we may have a problem, a challenge of them learning the system at fresh” – P9*) impacts the EMR implementation in Nigerian PHCs because the workings of the system will have to be reintroduced each time new staff are posted to the health centre. For this reason, it is appropriate for the implementer to plan the “train-the-trainer” strategy from the onset, where the EMR champions are trained to train their colleagues. If any team member gets posted to another PHC, the other trained colleagues can operate the system. The implementer should discuss this strategy with the management during the planning stage of the implementation. So, the management can incorporate the process into the culture of the PHC.

Patients

An interviewee perceived that the attitude of patients was noted as a challenge (*“The challenge that we may face during this implementation is the patients themselves” – P1*) to the healthcare staff.

The challenge that we may face during this implementation is the patients themselves. We've not even implemented this, they are shouting "it is their turn...", but we call something an emergency. When we have an emergency like that, we just take the emergency victim to the doctor straight away. But these patients will be telling us we are being partial, but to us, it's not partial because it's a priority. P1

Although patients might pose a challenge (“*these patients will be telling us we are partial, but to us, it's not partial because it's a priority – P1*”), they form an integral part of the EMR implementation because they receive the health services and are better positioned to give relevant feedback on the quality of care.

Subtheme 1.2 – Management and leadership

This sub-theme highlights the crucial involvement of the PHC management in ensuring the success of the EMR implementation.

Communications

Interviewees stated that there is an awareness by the management on the importance of the EMR implementation, clearly stating the aim and objectives of the system, collection, and input of data into the system to both staff and clients (patients). The participants also elucidated the various means of communications, including phone calls, SMS, WhatsApp and meetings (online and physical).

My action plan is that my nurses should be aware. That, creating awareness that the EMR system is coming on board. And they are aware but they don't really know much and we are just being introduced to it. P9

For the EMR, awareness is very important to all the staff, as well as the clients (patients), because sometimes we have to send them SMS, the awareness is number one. P8

We also have online meetings, which serves as a platform where we share information and all that. We communicate like face-to-face communication verbally. P2

We use the telephone, telecommunication. Like when she comes in every day we talk about anything, we talk with her on the phone. We can send WhatsApp messages. We use the telephone for telecommunication. Like when she comes in every day we talk about anything, we talk with her on the phone. We can send WhatsApp messages. P5

The role of communication (*“For the EMR, awareness is very important to all the staff, as well as the clients (patients), because sometimes we have to send them SMS, the awareness is number one” – P8*) is crucial to EMR implementation in Nigeria. Hence, it is vital for the head of units and leaders in the PHC to choose the appropriate channel to communicate the benefits of the new system to colleagues and patients. Moving from paper to electronic health system is a huge transformation that requires relevant explanations to manage the expectations of the relevant stakeholders.

Leadership qualities/style

The participants highlighted the importance of management relating and discussing with the team and assessing them based on understanding, which are qualities needed to implement the EMR system. Also, the staff noted the quality of supervision, openness, cooperation towards achieving a common goal and problem-solving orientation, friendly communication, listening, etc., leadership skills, which has influenced their efficiency in service delivery.

It is expedient of me to discuss, relate, assess what they're doing at every service point. What I see is I understand you and I relate to you with that understanding so I understand them, every one of them and I know how to relate with them. That's my style. P2

We have a logbook that we use to record patients. At times, when he comes, he checks the book to know if there's any mistake. If there's any mistake he put us through to correct us. "This is how you are meant to do it and this is how it is supposed to be. P3

She is an open person. If there is anything she needs to do she will call us, she seeks our opinion, she will go ahead with whatever we discuss. P4

I would say our Apex nurse's leadership style can be described as democratic type, she allows you to participate and air your view. P5

She allows you to air your view, give your suggestion, air your opinion then from that we can implement and achieve a common goal. When one or two people air their views on a particular subject it helps the health sector to move to greater heights. It (democratic style) also helps us in problem-solving, because sometimes nobody knows it all but the time two or three heads contribute, bring out their suggestion, we pull it together to achieve a common goal. P5

He's a very solution-oriented person. If there's a problem, he wants you to identify the problem and provide a solution. Even if you say, this is the problem. He asks: how do you want to solve it? If you tell him this is how we can do it. Even if you are not proffering that solution. Even if you are the one that identifies the problem, you couldn't provide the solution. He doesn't fold his hands. He's always very innovative and always looking for how to solve problems. Thumbs up for him. P6

I'm enjoying what I am doing it would be so easy to offer the services, the service delivery would be very smooth because we have a leader that is making us comfortable, it's easy to offer services to those that need it. We are so comfortable because we have someone who makes a job comfortable, you have someone who even motivates you to be better so it's easy to meet the needs of the people. P7

The leadership style that I put in here is simple to follow because if you are not coming down to their level, they wouldn't get what you are trying to put in them, so you must be a leader that listens, not an autocratic leader. I am a leader that listens to their complaints. P11

The leadership styles of the management (*"The leadership style that I put in here is simple to follow because if you are not coming down to their level" – P11*) goes a long way in influencing the uptake of the EMR implementation in Festac PHC. Thus, the heads of units need to establish a culture where the staff can feel confident to air their views and participate in the implementation process (*"She allows you to air your view, give your*

suggestion, air your opinion then from that we can implement and achieve a common goal” – P5).

Management buy-in

Two participants see the need for the local authority (LGA) to be part of the administrative system to facilitate prompt handling of challenges and the continuous running of the EMR system.

If the challenge is deliverables like the computers and all that with the buy-in of the local government too, I think they will always want to reconsider ("this is what we've started") and ensure that this will keep running. That is why, at the initial stage, I will want us to ensure that the LGA administrative system is also part of the system. I think I have addressed that. P2

My Apex nurse is there, she would communicate to the officials involved and they will give it to you – from the MOH down to the rest of us. When it was introduced, we accepted it in good faith because we felt like it should be something, at the end of the day, that will help project Amuwo Odofin PHC. P4

Since the EMR implementation happened in a public primary healthcare facility, the local government authority is main responsible for the facility ([Subsection 1.5.3](#)). Hence, it is necessary to get the backing of council leadership (“*If the challenge is deliverables like the computers and all that with the buy-in of the local government*” – P2) to ensure the success of the implementation.

Incentives

Two participants noted that the motivation of the Festac PHC management is optimum service delivery, not monetary gain. However, it was proposed that awards could be given to the outstanding staff for actively engaging the EMR system at the end of each year.

Actually, I don't believe in monetised incentives actually and as professionals, we work within the healthcare system. It is our job, this is our call, this is what we do, I think the only incentive I think that I might propose to the management is like an end of the year award to the staff who is actually doing fine when it comes to the EMR system. It would help people or motivate them to do more. If you start giving them money, when the money stops, that is when the system begins to crumble. P2

No monetary, nothing – nothing. At least, knowledge is the gain. P3

Incentives (“I think the only incentive I might propose to the management is like an end of the year award to the staff who is actually doing fine when it comes to the EMR system” – P2) serve as catalysts to rapidly adopt most kinds of change in various human settings. However, incentives do not prove effective in the long term because the recipients tend to depend on such gestures or view them as an entitlement, which may hamper productivity. A key incentive for the EMR implementation will be that the new system helps the HCPs perform the roles efficiently and effectively.

Subtheme 1.3 – Operational

This sub-theme relates to the day-to-day running of the health facility in preparation for the EMR implementation.

Workflow

The workflow entails the routine tasks carried out by HCPs and the management in delivering health services. A participant remarked that they administer treatments to patients while another collate reports from the health facility and transmit them to the relevant offices for planning, training and administration. Two participants reported that they perform monitoring and evaluation activities such as ensuring proper documentation, supervision, reporting and decision making for aggregate health data.

We take vitals and administer the treatments based on the doctor's prescriptions. Then we do outreach services, we do go once a week for outreach services then we track the defaulters. P1

The report I collate, I collate the report from each PHC. They bring the report, I pull everything together and write a single report including Oriade LCDA and I send to the primary health board. And at the primary health board, we have our meeting once in a month, and at that meeting, we summarise all that is happening in the local government and we send a single report so that they have an idea of what is happening in the Festac PHC and Oriade PHC. At the end of the year, we write all that we have been saying from January to December, we write it out and we submit it. P9

I think my role is just to take the vitals of the patients, then transfer the patients to the doctor and whenever the doctors write anything for the patients, my role is to give the prescription that the doctor makes to the patients. P1

I do monitoring, I do supervision, I assess and I evaluate. So, I do report writing, I do it monthly, quarterly, bi-annually, annually. I do meetings, I do training, I go to workshops, I do a lot. P9

I am a health information manager. I assist the health information technician. I oversee what they do there in terms of documentation and registration of patients in terms of filing and retrieving. I also work as the assistant M&E officer which is a monitoring and evaluation officer. What I do is beyond keying of data to the system. I also make reports and make decision in regard to the reports. P6

These findings suggest that the clinical workflow needs to be understood from the HCP perspective (“*What I do is beyond keying of data to the system. I also make reports and make decision in regard to the reports*” – P6) to inform the design of the EMR system. The system should be designed to cover the clinical activities, ensuring that it can adequately capture the data derived from such activities. Therefore, the captured clinical data will be readily available for routine and administrative use.

IT literacy/EMR knowledge

Two participants alluded to the notion that most HCPs in Festac PHC are computer literates (“*I think the majority of us are computer literates*” – P1) and have some knowledge of the EMR system (“*I noticed they have knowledge of the EMR*” – P2). However, another participant sees the EMR as an opportunity for personal development (“*my knowledge in software programming will be highly elevated*” – P5).

So then I think the majority of us are computer literates. So, I think with these skills that we have and the staff that we have it will work. P1

I think the knowledge is also key, resources that I think we have too, a lot of us, even if someone has not used the EMR before as the M & E officer who has actually discussed stuff like this with them, I noticed they have knowledge of the EMR. P2

If my assistant has a very good knowledge of the system itself, when a problem arises, though we may still have to call or notify the implementer of the system, there will be some little problems I think we should be able to solve at our own level. So when we don't have the capacity to solve them then we call the implementers. P2

It will help a lot with my personal development. At least with this EMR, I am going to say at least like this collection, new software devices that I've not seen, and my knowledge in software programming will be highly elevated. P5

These views (P1, P2 & P3) highlight computer literacy level and the knowledge resource of the HCPs as prerequisites for using the EMR system and as an opportunity for skills development in Nigerian primary care.

Training

A common emphasis among the interviewees is the need for training and retraining to sustain the operational use of the new system. The call ("*So far, you've given them a laptop, you know they need to be trained on how to use it*" – P11) is due to the culture of HCP transfers and their (HCPs) willingness to accept the training.

So far, you've given them a laptop, you know they need to be trained on how to use it, training and retraining because you know as government officials, they transfer in and out, so when they are being retrained and trained. P11

If it happens, we are failing we should ask where is it coming from? Is it that you are not getting it you need more training, or you don't like this system you need another one to come? Is it that you are not getting it? You never can tell but we are not praying for failure, but we can plan towards. It is about that training, everything is not about money, but it is about that training. Are you knowledgeable enough? Have you given it to them? Have they digested it? Can they come one on one to support you? P4

As an M & E officer, the State has actually injected a lot in me, through training and all that. P2

According to the management, they are going to give us some training. So, with that training, we will be able to do more. P3

By giving us the necessary information even if it means calling us, or telling us site to go and read more, or giving us paper to read or information or whoever we should call or whoever that would give us training, so that we would be able to know it well you know. P4

If people don't have an idea of what something is and you can put them through to do it, it would definitely work. P7

The doctors, the nurses, all the health workers, should actually be trained properly, training and updating, updating from time to time. P8

Although there was a consensus among interviewees that HCPs have required IT skills, the management should prioritise the training and retraining of staff (“*The doctors, the nurses, all the health workers, should actually be trained properly, training and updating, updating from time to time*” – P8). This effort is significant because the HCPs need to be up-to-date in using the EMR system to improve care delivery. Moreover, continual training can address the gap of staff turnover identified under the Organisational culture subtheme ([Subtheme 1.1](#)).

Communications (to patients)

One participant said short message service (SMS) is a quick way of confirming appointments and sending reminders to patients. In contrast, another participant commented that Information, Education and Communication (IEC) materials from the

government or any health partners are pasted on the notice boards with proper orientation to communicate to patients during appointments.

The patients will be able to get quick SMS to confirm their nurse visits, and some of them that have forgotten. That we also ask, a patient is due for appointments, we communicate to them, and that we will allow them to come to the centre, yes. P8

Information, Education and Communication (IEC) from the government or from any party to the patients on papers that we put on our boards, for the patients to really understand this is how we are to do this or that, from one end to the end, maybe when we are giving health education, we just point at the IEC materials. Then it would make them understand what we are saying or trying to pass to them. P9

These comments imply the possibilities of integrating the SMS feature into the EMR system, mainly owing to the widespread usage of mobile phones among patients/citizens. Although the SMS feature (“*The patients will be able to get quick SMS to confirm their nurse visits*” – P8) integration seems promising, integrating the IEC materials appears to be a far cry because the patients do not interface with the current system.

Maternal and child healthcare

The participants identified EMR as a potential tool to help HCPs track and manage ANC and immunisation defaulters in the maternity department.

The defaulters are the people that they give appointments to maybe to come because we and the maternity department and other departments. Like if they give children immunisation they ask the mothers to come back to give them next visit so we track the defaulters, the defaulters are the people that they give the appointment to, the next appointment, and they don't come. P1

So we try to trace their house, call them on the phone to make sure they are back and if they don't come back they give us the reason for not coming back like maybe they are attending another health facility or they travel so we track the defaulters. P1

It will also help us, the health workers, to know when patients are not available to access their treatment, and when to inform them to get to the centre, and also to track defaulters. P8

We have a decentralised record system. At the end of the day, we still have all the records on the registers. Yes, we have a register given to them so that we can track how many ANC patients are new or old for the day. The ANC is done on Mondays. At the end of the day, we go to collect their records so as to be able to document them. P6

If you say we should pack them together, then we will not be able to ascertain the records. They'll be attended to separately so at least it will make the work easier. P6

There is a problem with tracking defaulters using registers (“*At the end of the day, we still have all the records on the registers.*” – P6). Since the EMR implementation aims to transform paper health records into electronic health records, the digital transformation will improve the current management of defaulters on paper registers.

Referral

The participants commented on the standard referral policy for patients whose medical history or current conditions are beyond the available medical expertise in the PHC. With the EMR implementation, the interviewees said that HCPs could refer patients promptly and quickly to a secondary level of care.

Like a patient came in and she has a history of previous operations, previous appendicitis, we may not be able to attend to, we refer them because the scar is there. If anything happens and we are unable to handle it, we refer them. P9

If we see a patient with signs of preeclampsia like oedema (swelling/fluid on the feet), when we apply pressure, it will show. There are two other signs: when we see that the blood pressure is high, we note it. When we take the urine and we know that there is protein in the urine. it is the three signs we look for and immediately we see two out of the three, we refer to the secondary level. P9

The same issue of referral. We are talking about the patient who was around was given an anti-hypertensive that has part of its components amlodipine you now. We're not too sure what we would have done. With an EMR, we could quickly link up or look up the last referral and get their exact information. The woman herself, she's not sure of the medicine. In the long run, we had to advise that she go back home, come with the medicine and say tomorrow we can attend to her. So if we have to go through the books, through the prescription sheets, it's going to take a whole lot of time. So with an EMR, I think that aspect can be resolved. P10

We will be able to refer to issues that have to do with adverse drug reactions in patients you know in which you relate with drug incompatibility for these patients. P10

These views have shown the limitation of a manual referral system. The issues (“*We will be able to refer to issues that have to do with adverse drug reactions in patients you know in which you relate with drug incompatibility for these patients*” – P10) vary from medical history to conditions and prescription to drug incompatibility. The electronic system can flag and help manage these issues for the HCPs through the relevant functionality. Ideally, there should be interoperability between the EMR systems in primary and secondary health facilities. Unfortunately, interoperability is still a significant issue not only in Nigeria but other LMICs and HICs.

Health information unit

One participant submitted that the EMR system is key to the health information unit.

I think when it comes to EMR the health information unit, the medical records unit is key to the system. P2

I think it's important that it will broaden the knowledge of those who work within the health information unit. so because after the implementation and the key implementer has gone I think these are the ones they will call often. P2

Arguably, the medical records team are central because they are the unit in charge of the EMR system (“After the implementation and the key implementer has gone, I think these are the ones they will call often” – P2). They maintain the records, produce and transmit the aggregated data to the national health management information system.

Busy workload / Data entry issues

Interviewees expressed the concern of work demands in terms of writing and typing. However, the advantage of EMR implementation over paperwork was clearly highlighted in terms of backup, easy data entry and retrieval, solution to illegible writing etc.

Initially, my reaction was that this thing will be too stressful. If we enter the patients into the computer, it will still open the file again. Can't the work be made a bit easier for us, that we stop using paper files? P12

EMR provides ... you can always get it back from the back-up. Illegible handwriting of the medical officers by wrong description, wrong diagnosis. P14

I was glad because of the stress of the folder searching I was glad when they told me that's why we have been expecting you people to come and do it. P13

I think I will suggest that the doctor should have someone that will be typing when attending to a patient so that he will be able to concentrate, to know what he is discussing, or what the patient is discussing with him. P3

When you are writing, as a patient is explaining it some things, you can pause and listen very well, and know what kind of drugs you will be able to prescribe for that patient. The patient is explaining and you are typing at the same time, it's like you are not concentrating on what the patient is discussing with you. P3

Because of the difficulties we have you know to write requires more manpower but with the use of this EMR one person can do multiple jobs. P5

If we are using EMR and a doctor is on duty from morning to now, seeing about over 20 patients, the doctor will be tired, and they won't be able to input. So, maybe the MOH can help to see how the doctors can be available. Fatigue can set in. He has been working since morning, talking and cracking his brain to see how to give a patient medication that will suit the patient's situation. If you are tired, there's no way you can even use your hands if your brain is just tired, you can't use your hands. P6

I feel like we should address the consultation workflow. That's the main and major - yes, they're the key persons in this facility. If we have 10 or 20 or 30 patients, and we only have one doctor to attend to them, to send them for the lab. He might say, I'm just tired, this one can just stay/leave if they want. P6

Handling paper records is already a demanding task for HCPs (“*Because of the difficulties we have you know to write requires more manpower*” – P5), especially doctors. With the low doctor-to-patient ratio in Nigeria, doctors’ workload is high and forms a basis for their resistance to the EMR system because they view the system as an added burden (“*If we are using EMR and a doctor is on duty from morning to now, seeing about over 20 patients, the doctor will be tired, and they won't be able to input.*” – P6).

Subtheme 1.4 – Technical

This sub-theme relates to the availability of the technical infrastructure required for the EMR implementation.

EMR is essential to do work

The comments below illustrate the participants' concern for the EMR failure despite its overwhelming advantages. Moreover, the participants highlighted patient information is critical to service delivery and will be the worst hit if the system fails. However, they suggested that there should be a backup plan as a part of the implementation to ensure continuity in eventualities.

If this project fails, we are going to lose a lot of the information of the patients, and it's going to affect the workers. P3

I took my time sometimes to actually complete an Excel database that can keep patient information like bits especially when it comes to their biodata. So when it comes we won't be looking about for folders and all that I know that is not enough but that is what I can do at that point in time. P2

There is power failure, in that process, at least we have a small notebook that we can get with our use, to get some the data of patients that also come, that is our daily logbook. We will still be using it in case of something like this happens, so we can go back to it, to get the information of the patients. P3

EMR is not just for the pharmacy it will link other departments, other units so if I have to relate with the lab, for instance, I can just come and see what the lab has in relation to what I'm doing in pharmacy and other units also. P10

It will make our work to be faster and effective within ourselves instead of carrying one file from one table to the other. So just immediately the patient comes in; they go straight to the doctor instead of carrying files here and there. P11

Once the EMR or any IT system is fully operational, it becomes indispensable because the workflow is built around such a system. The EMR implementation adopts a parallel approach where the system is used alongside the paper records in this study. The paper system serves as the most reliable backup (“*We will still be using logbook in case of something like this [power failure] happens, so we can go back to it, to get the information of the patients*” – P3) while the electronic system undergoes testing.

IT Infrastructure/Electricity

Participants identified computer, internet connectivity, LAN, electrical power source, among others, as key components for a successful EMR implementation and its continuous running.

We need a computer, we need internet connectivity, we need the LAN. P2

Failure will happen because of electricity. If there is no electricity, it will affect the workers. Availability of electricity will make the EMR successful. P3

Everything will move on smoothly and if there is something like power inverter (backup electricity), it will support the system in case there is no electricity. P3

The network system, which may be a problem, but I don't know if antennas can help to bring out signals. P4

The only thing that can hinder us is electricity. P6

Internet or broadband data too, the data must be available. We don't want a situation when the data finishes, for us to get another one may be difficult. P11

Poor infrastructure is commonplace in Nigeria, as with other LMICs. Without the vital infrastructure, the EMR implementation will not stand (“Availability of electricity will make the EMR successful” – P3). For example, constant electricity or a reliable power supply backup, IT equipment and networking should be in place before the implementation. It is possible to implement EMR on a LAN connection without constant internet connectivity, although there are a few shortcomings.

5.5.3 Theme 2 – Expectations for the EMR and its impact on health service delivery

A recurrent theme in the interviews was a sense of expectation among interviewees that the EMR system will support their work and provide value for health services.

Quality healthcare service delivery

The interviewees expressed optimism for the EMR system to support quality healthcare service delivery and better outcomes.

We want it to improve our health care services in terms of statistics, patient flow and accuracy. P9

As beautiful as the laboratory order is, when they send it they get it on time as fine as the prescription is, I think these areas need to be addressed actually at least we can monitor the laboratory and the pharmacy. Not just in terms of quality of care but also in terms of logistics. P2

It would help to better our outcome in healthcare services and help us to perform better and it would give us some skills, digital skills. P9

It's important because it's our day to day activities, to me it's my day to day activity, because I need information and to get information, it is through the system. P3

So, in the coming years, our vision is, we want to see a better performance in terms of the patient-doctor relationship. P6

You've mentioned tracking of prescription it's an aspect that needs to be addressed really and also, I'm hoping that through the EMR. P10

The participants alluded (“*We want it to improve our health care services in terms of statistics, patient flow and accuracy. We want to see a better performance in terms of the patient-doctor relationship*” – P9, P2) that EMR can improve the quality of healthcare delivery. This expectation is due to its efficient processing of clinical workflow from one service point to another in the PHC setting. For example, the HCPs can access patient and clinical data for routine or scheduled treatments using the EMR system.

Saves clinician time

Interviewees shared that the EMR system is expected to introduce efficiencies for clinicians in terms of time savings, reduced personnel and energy utilised on clinical tasks.

EMR also gives direction and that direction helps in terms of cost-effectiveness and efficiency. P2

Then it reduces the excess writing and manpower resources because one person can easily cover a wide range of individuals in a little minute of time, so it saves time, it saves manpower, it saves energy. P5

I cannot say categorically that we have a very nice efficient flow. I think EMR will also help us to solve that. P2

EMR and most IT systems are known for their efficiencies (*“EMR also gives direction and that direction helps in terms of cost-effectiveness and efficiency”* – P2), but sometimes it depends on how these systems are implemented. At times, there might be bugs in the system that requires the support of the implementers. While the fixes are being carried out, they usually come with delays in the clinical operations that rely on the system. Hence, the clinic might eventually resort to paper until the system is fixed.

Reduced stress

Two interviewees expressed the desire to cut down work-related stress minimally and believe that the EMR system implementation will handle that.

We want to reduce all this stress of looking for folders, even the staff there are times, the times they spend on folders, to look for the folders will be reduced, the stress will be reduced. P1

It would reduce the workload. At first it might be stressful, but eventually it will reduce the workload. P14

Managing paper health records is known to be demanding, especially when there are a lot of patient files to go through. It is logical for the HCPs to welcome EHR to save the stress of locating patient folders (*“We want to reduce all this stress of looking for folders”* – P1) each time a patient visits the clinic.

Saves healthcare costs

Participants state that the EMR system will save healthcare costs of paper, printing and the risk of transporting sensitive materials (*“We get files for our patients at an expensive cost and the risk of transporting some IEC materials to the health centre for the patient”* – P6).

When there is an EMR system, I don't think the worker wants to collect money from the patient. What for? They can't ask because they are using the system, not cards again. So I think it will help here too. P1

It will save cost on the production of these papers - plain paper or continuation sheets, for us to write patients information. P6

We get files for our patients at an expensive cost and the risk of transporting some IEC materials to the health centre for the patient. This would help reduce those costs for the government and for the centre and even when we need to do programmes, we just sort it the information, give it to the nurse and we pass this information to them to have these skills directly, instead of going through written papers. P9

Although the initial cost of implementing the EMR system is high, it reduces the administrative costs of maintaining paper records (*"This would help reduce those costs for the government and the centre" – P9*). At the same time, it is ideal for the management to adequately plan their finance to include the EMR costs not to affect other clinical areas.

Reduced waiting time

There is a common voice between the two participants that EMR will reduce waiting time for patients.

The quality of care actually starts from even the patient waiting time itself. So, the EMR will help us to know the time this patient is actually spending and if they are actually spending more time than necessary in hospital. P2

It reduces the waiting time and the timing in attending to the patient to give the service delivery. P7

Patient records will be easily accessible with the introduction of EMR, which helps in improving patient wait (*"EMR will help us know the time this patient is spending and if they are spending more time than necessary in hospital" – P2*). However, patients may have to wait longer during system downtime if no paper backup is in place.

Healthcare audit

One participant argued that the EMR system would serve as a healthcare audit tool for service delivery management.

I'm very sure EMR is just the same as the audit tool for service. The EMR at the same time in terms of quality care will help us to audit exactly the type of care we're actually giving to this patient or client irrespective of where he gets it or who is discharging the services. P2

The EMR must be able to track, you know, tally them as appropriate and give the report of all vaccines and antigens given to these children, immunisation, the report from that end has been very traumatic, you understand. So immunisation is very key. P2

It is challenging to do health audits with paper systems (“*The report from immunisation has been very traumatic*” – P2) but much easier to do electronically (“*The EMR must be able to track, tally as appropriate and give the report of all vaccines and antigens given to the children*” – P2). Hence, it is less time-consuming, and the EMR system can process clinical data from different departments faster since they will be located in the central database.

EMR qualities

The interviewees underscored that documentation and communication would be simplified by the EMR system, which will aid tracking, diagnostic treatment, report writing, among others.

Documentation and communication, I think it is what the EMR has come to simplify. These are the aspects that EMR would simplify and this is what we are battling with over the years. And I'm seeing it as a big leap for us in the health centre. P10

It (EMR) would be good for tracking. At least when they book patients for the next appointment on the system you can easily see that this patient has defaulted, easily. So it will help out tracking. P1

I think it will help us in many ways and it will be easy for the diagnosis and treatments. When this programme is successful, the patients will know that there are changes because their diagnosis and treatment will be good. P1

Then to my work here it will make it easier, achievable, going on smoothly, for Lagos State anytime they need information, with the EMR it can be provided faster. It is a very good development. P4

The EMR system, to me, I understand it as an innovation, a programme that is aimed towards the collection of patient records and putting it in an electronic or computerised device that will help for easy collation of data. P5

When collecting data and report writing, it makes the work very easy. At the end of the day, the computer will automatically programme it and correct the data for you and it makes the work very easy. P5

We can give account or we will be able to give information and not delay the M & E Officer, my Apex or anyone. P4

It will possibly be one of the numerous advantages of EMR because if a patient, for instance, won't have, there are issues around it but one that comes to mind is a patient won't have to repeat a particular test over and over because it is always difficult to get the record in this instance when we have to pile up papers and all this keeping of papers and registers. P10

The features (“A patient won't have to repeat a particular test over and over, and this will possibly be one of the numerous advantages of EMR” – P10) of an EMR system are numerous depending on the implementation scope. They include data collection, reports collation, data storage, data sharing and decision support capabilities, to mention a few.

Paper records issues (e.g. misfiling, data loss, privacy)

Participants were optimistic that EMR would resolve all paper record issues and desire to advance technologically in healthcare delivery.

You just use the times you use to attend to patients and you know to get the pharmacy job done for the benefit of the patients, you have to be looking through papers and imagine if you have so much heap that you can't discard for three years. So today it doesn't speak well for pharmacy operations. So an EMR would resolve all these issues. P10

We said we don't want to use all this paper, paperwork, writing! writing! We don't want it again. That means we are still going back. P1

The file that we have misplaced and packed/archived - that means we are going to bring them out. So, it is a very huge consequence. P1

Using paper records especially in Festac PHC where we register them as a family one of the problems we are having here is continuation sheets inside the folder can be used for two or more members of the family which normally is not good statistical-wise. So while you are treating a patient you're also seeing another patient's history. P2

It will affect accessing data for future, present and future, because data should be past, present and future. When staff retires people who are taking over I should be able to access the data but when it's not available it will be bad, it will be bad. P8

+ We have some problems with filing and at a point, we want to read some folders, take them out here and all that. I think the EMR system will come to reduce the burden on us actually. P2

+ So, there's a mix-up in diagnosis where you can't even find the past results. The past information of the patient you can't locate it, but with this (EMR) now all the results are in one place. P7

+ Our backup, our paperwork will still not be discarded because we know that if something happens, we have something to fall back on. P6

From all the indications, it is evident (“*We have some problems with filing and at a point, we want to read some folders, take them out here and all that*” – P2) that the HCPs in Festac PHC are tired of the paper records. These issues are not just peculiar to Festac; other manual health systems experience the same. The EMR system will not magically resolve all the problems with paper records overnight, but the digital transformation will gradually happen. Participant #6 sounded realistic, saying, “*Our backup, our paperwork will still not be discarded because we know that if something happens, we have something to fall back on*”.

Data is key (including data quality)

The participants shared a consensus on the importance of data in making clinical decisions. They commented that stakeholders could not fully achieve data quality and integrity using the paper processes but remarked that the EMR system could handle this issue seamlessly.

When it comes to the decision making in health, data is the foundation, or the key, or the backbone but when we don't have data that we can fall on or rely upon due to some human errors and errors that shouldn't exist. P2

I think decision making-wise, EMR will help us to make quality decisions and this will in turn help the healthcare system in general. P2

I believe that the quality healthcare data will lead to quality healthcare. P2

Our data would be collected perfectly. There wouldn't be an omission of names and other details. it will be collated, you have a perfect record and an accurate record. P5

It is a way to get proper, complete data. I think the EMR will help us in such a way that our data will be up to date and then there is going to be a correlating data, in such a way that we don't have separate data coming in and a separate data from another angle so by the time we get to correlate the data that is not always tallying. P7

Vision is to have correct data, input correct data. When your data is properly prepared, helps the clients to access their treatment properly. P8

Paper or EMR system does not guarantee data accuracy (“The vision is to have correct data, input correct data. When your data is properly prepared, helps the clients to access their treatment properly” – P8). It depends on who and how the data is collected. EMR will efficiently process the data entered into it but could be a case of garbage in, garbage out.

Festac PHC as a point of reference

The interviewees shared their hopes that Festac PHC will serve as a digital exemplar for other PHCs implementing the EMR system for quality healthcare service delivery.

I think Festac PHC will only serve as the pilot site. So if it works fine, which I know it will work fine. P2

My vision is to extend this to every other facility within the local government here and in turn, extend to the state in general. P2

Even in the community, they will prefer to come to Festac PHC because “when I go there, they attend to me, faster, for the fact that they even use a system, computer”. “So I don’t have a problem if I don’t see my card, I know I am accessing care. P2

Festac PHC can then be a role model in Lagos State for better information sharing. They can come here and learn and reproduce/replicate the same. P6

We hope one day that if the State thinks of implementing a digitalised health programme, Amuwo Odofin can be a case study. It should be that it is nothing strange because Amuwo Odofin has been using it for a couple of months or years. P10

Festac PHC is projected to be a leading force in digital health innovation in the State (“We hope one day that if the State thinks of implementing a digitalised health programme, Amuwo Odofin can be a case study” – P10). It is the first public PHC in Lagos State to go electronic with their health records. Other PHCs, mostly having similar structures to Festac, can learn from the EMR implementation process (“They can come here and learn and reproduce/replicate the same” – P6).

Patient information retrieval

Participants perceived that the retrieval of patient records will be easier and quicker with EMR than the paper records system.

I think it also helps us to make the records constantly available. P1

With EMR, if I'm looking for something that is not attached to the current reporting form, I can easily command the system to do such information retrieval. P2

This one is not the one you say "since I have been looking for this information". At worst, if the information is missing, the one you have written you go back to reprint it (EMR) will make our job easier, effective, efficiently, up to date. P4

With the EMR, we can have access to the test the patient has done. Even with that, you can help to access the patient's history. Maybe we want to look at two to three years back, we can access the history. P6

Even if the patient cannot give a comprehensive answer or yes or no, even if it is an open question, yes or no answer, the doctor is aware that from the system he can look back and view the history of the patient. P6

The ease in retrieving patient data is crucial to an efficient workflow for HCPs in Festac PHC (*"If the information is missing, EMR will make our job easier, effective, efficiently, up to date"* – P4). As long as there is a proper maintenance, security and backup plan, EMR is a perfect system for data retrieval and provenance. The system allows access to patient records, which helps the HCPs to make informed clinical decisions for better outcomes.

Patients' confidence in the system

Participants commented that there is an assurance of patients' confidence in the primary healthcare system with the EMR system. They are assured of patient safety, satisfaction, confidentiality, data security, privacy and no out-of-pocket costs. The patients are good advertisers who will promote the effectiveness of the system.

At least, when the patient comes in, he or she makes the complaint at least to provide the care that would satisfy that patient. P1

Instead of you treating a patient for, let's take, for instance, somebody who has a history of diabetes and a family member who is not diabetic now came. Because you are seeing a diabetic history at the top of the continuation sheet, you are now taking it as if you are treating a diabetic patient. EMR will erase that because you are servicing a patient as an entity, a unit. That is one thing EMR will do. P2

We don't want the situation where patients will start shouting, saying all sort of things, saying that we are not doing our job. P3

Then the patient will be able to be self-confident, say even if I forget my card, I don't need to open another card because the hospital has now stepped-up and they're now using EMR, then they will be able to get my file. But they won't be saying, okay, it means I have to have another cost, or I have to pay for another revenue or pay for another cost for me to access care. P6

If it is bad news, they (patients) can spread it and if it is good news, they spread it too. P6

I feel the patient will feel safer here because there is an improvement in the quality of care and they get to enjoy more of the quality we can give so to speak. P7

It [EMR] prevents any third party, an external person to get a hold of their result and use it against them because we had so many issues of people who are not even medically inclined because they want to get back at someone or maybe they just want to try and maybe "dub" yeah. P7

It [EMR] will give them more confidence that yes that their history is not flying around. It will give them a curiosity that there is security for their folder and privacy. P11

There is a feeling of security and dignity when patients realise that their data is stored safely and securely ("*EMR will give them more confidence that yes that their history is not flying around*" – P11). Unlike the EMR system, staff can expose paper folders in a typical Nigerian public health setting to several unpleasant conditions.

Primary healthcare research

Two interviewees agreed that the EMR implementation would encourage clinical research and provide data for statistical analysis.

With my sense of EMR, I know even right from the table of doctors I know that EMR helps in research, EMR actually helps in research. So I expect EMR to come in here and help us. Though it is a primary healthcare health centre. I think research in primary healthcare level is so poor so if we have an EMR and existing EMR in a primary healthcare centre easily we can do a lot of research because a lot of diagnoses are seen, a lot of cases are seen at the primary healthcare level and we are not taking cognisance of. P2

With EMR it's easier for us to have our statistics ... it's easier for us to plan, to make projections. Okay, how many patients are we seeing in a month? We can do an analysis. Let's say over 1,000 patients, and we can, based on what we are ... instead of paper ... the paperwork can be misplaced but this one because it's guided electronically, then it can help us to make such plans. Especially at the hospital, we can plan for ... okay, since we are seeing 1,200 patients in the attendance, okay, what are the resources that need to be in place, maybe doctors or maybe other medical attendants. So, we can make projections based on the number of patients that we have, so I think that's it. P6

EMR is a significant source of routine clinical and administrative data for research (“if we have an EMR in a primary healthcare centre, we can easily do a lot of research because many cases are seen at the primary healthcare level” – P2). For this reason, the clinic can use these data to improve treatments and diagnoses and audit attendances to help make projections or identify treatment patterns for quality patient care in Nigeria.

5.5.4 Theme 3 – Sustainability of the EMR implementation

A common view among participants was that sustainability is central to the success of the EMR implementation. They want the system to continue to work considering the extent of the implementation and are willing to support the process.

It [EMR] is a welcome development if only we can sustain it. Sustainability is key. To introduce a project like this is a very big job but sustainability is another one. P5

Our vision is that we want the EMR to continue like this, we don't want to stop it, we want it to be constant. P1

We won't let this thing to collapse, we will try out best to make sure that everything works out fine. P3

Sustainability is a known issue in developing contexts; the EMR implementation in Festac PHC is not an exception (*“EMR is a welcome development if only we can sustain it. Sustainability is key” – P5*). The management and the HCPs have the desire that the system continues (*“Our vision is that we want the EMR to continue like this... We won't let this thing collapse” – P1, P3*) but lack the required financial commitment.

The participants identified some issues regarding the sustainability of the EMR system, which centred around funding, monitoring and maintenance.

We move from incentives to the government embracing this kind of thing, where each primary and secondary clinic we look forward to where the government give them money for this incentives and encourage and even sponsor the training so that everyone can have this EMR system for the sustainability and the process. P9

If they [management] can provide funds, I mean motivation for the staff and also funds to sustain the systems. P14

Yeah, because is it going to be monitored by you or us? Assuming we have a problem with the server even with the electricity, so I think it has to do with the internet. It should be monitored by us so that is our plan. If we have any challenges that we are facing about this, we have prepared ourselves. P1

Yes, the maintenance, well you must have standby maintenance, since it's an electronic system, it can go off, to avoid break there must be maintenance support. P8

Everything will move on smoothly and if there is something like power inverter (backup electricity), it will support the system in case there is no electricity. So it will be more of a success than a failure. P3

Sustainability requires continuous funding (*“The management can provide funds and motivation for the staff to sustain the systems” – P14*) and accountability at all levels. The complex nature of EMR implementation calls for an adequate understanding of the requirements, robust assessment of the clinical processes and firm commitment from stakeholders to ensure the initiative's sustainability.

5.5.5 Discussion of key findings

The extensive thematic analysis showed the importance of integrating the health care practitioners in the planning and implementation of the EHR system. The in-depth

insights from the participants provided a practical understanding of implementation factors such as the health context, clinical workflow and expectations for the EHR, relevant to the pilot study.

5.5.5.1 Readiness assessment of Festac PHC

Heraclitus, the Greek philosopher, said, “*Change is the only constant in life*”. As accurate as this statement may seem, people do not accept change the same way, mainly when it affects their usual way of working. If change is bound to happen, then there needs to be some preparation for such change. As suggested by an interviewee, one way to prepare was to conduct a situation analysis to understand the perceptions of the staff about the change from paper to electronic health records in Festac PHC. Some participants expressed their willingness and commitment to learning is instrumental to the full operation of the EMR system. Having such a positive attitude was linked to the success and continuous use of EHR for quality care delivery in small health facilities (Begum et al., 2013). The use of incentives to influence the adoption of change is not usually effective in the long run because it might encourage an attitude of entitlement in HCPs. Adequate training, dedicated IT support, and incentives have been identified as healthcare providers factors that affect the uptake of EHR implementations (World Health Organization, 2019). Although some participants expressed concerns about additional workload and data entry issues, others claimed that EHR is essential to do their work efficiently. Studies have suggested using data clerks or scribes to record data into the EHR to address the workload concerns of HCPs during the implementation (Howard, Helé, Salibi, Wilcox, & Cohen, 2012; Muinga et al., 2018). Detailed discussion on data entry alternatives for EHR implementation can be found in [Subsection 6.4.3](#).

5.5.5.2 Expectations from the EHR implementation

The interviewed HCPs had very high expectations for the EMR implementation and were eager to make it work. Such responses were not too surprising because the paper records inefficiencies slowed down work for the staff. EMR is known for its efficiencies to clinical workflow regarding reduced waiting time for patients, saving clinician's time

and clinical data management. These efficiencies sometimes take a while to manifest because several studies adopt a parallel deployment approach where paper and EMR are used simultaneously until the users are very confident of the EMR. It is not unusual to experience system downtimes resulting from bugs in the software or hardware failures. It is incumbent on the stakeholders to strategise appropriately to avoid any significant breakdown in the clinical operations. Although EMR saves clinicians' time, this may not be the case in the early months of the implementation due to the workload or data entry issues. Stakeholders should have a long-term view of deriving EHR benefits so that they are not discouraged by the teething problems that may arise.

Moreover, there were high expectations among HCPs that EMR is a silver bullet for data issues. While it is right to assert that EMR processes data better than the paper system, one must be cautious of the human errors during data entry. Hence, EMR is expected to yield the desired results if adequately implemented by considering key implementation factors in the relevant settings.

5.5.5.3 EHR sustainability

The enabling environment within a setting goes a long way in determining whether the implementation of a system will be sustained. LMIC settings are known for the lack of adequate infrastructure and funding accountability, poor policy decisions, interoperability issues shared with HIC settings, inadequate training of health personnel, uncertainty regarding privacy and security and lack of regional integration. The relevant stakeholders can address these issues by ensuring adequate infrastructure and funding accountability, implementing the appropriate national health ICT framework, learning interoperability lessons from HICs, providing sufficient EMR training for the health workforce, promoting data privacy and security, and encouraging regional collaborations (Luna, Almerares, Mayan, González Bernaldo de Quirós, & Otero, 2014). Therefore, there is a need for relevant stakeholders to strategise early before commencing any digital health implementation.

5.6 Technical implementation and system evaluation

5.6.1 OpenMRS demonstration

There was a demonstration of the OpenMRS software during the first stakeholder meeting (Section 4.4.2). The activity helped the practitioners have a feel of how the intervention works. Before this meeting, the contact person from the PHC had been testing the demonstration; they gave feedback on what the PHC specifically wanted.

5.6.2 EHR application features and relevance to clinical workflow

As with most EHR systems, OpenMRS consists of clinical modules, dashboards and forms, which are customisable to support different aspects of clinical workflow in the health facility. OpenMRS comprises functional clinical modules for patient registration, patient visits, vitals capture, clinical notes, appointment scheduling, electronic forms, and reports. This study implemented these modules for different service points (locations) in Festac PHC. The service points in Festac PHC are the mother and child centre, health records, consultation, general outpatient, laboratory and pharmacy units (see Section 4.4.1 for detailed description). Table 19 describes each module/form, its purpose, the data elements captured and the applicable service points for each module.

Table 19: EHR software modules/forms, data elements and relevant service points

Modules/Forms	Purpose	Data elements	Service points
<i>Register a patient¹</i>	Enables the registration of a new patient (e.g. mother, child or regular) by collecting relevant patient information.	Patients' personal/demographic data (e.g. name, gender, date of birth/age, ethnicity, occupation and education) and contact information (e.g. address, phone and next of kin).	Mother and Child, Health records
<i>Find Patient Record</i>	Enables the search, retrieval and editing of existing patient records by entering patient name or ID in the search box. Displays a dashboard with patient information.	Patient information (e.g. registration, visits and appointment data).	All service points (based on user-assigned views and privileges)
<i>Active Visits</i>	Shows the details of patients that are currently visiting the health facility.	Details of active visits (e.g. patient ID, name, check-in, last seen and type of visit)	All service points
<i>Capture Vitals</i>	Allows the nurses, midwives and doctors to enter vital signs of a patient after registration or during clinical visit.	Vitals data (e.g. height, weight, calculated BMI, temperature, pulse, respiratory rate, blood pressure and pulse oximeter)	General outpatient Consultation
<i>Appointment Scheduling²</i>	Supports the scheduling of appointments for patient visits such as ANC and outpatient clinic.	Schedule and appointment data (e.g. provider schedules, appointment requests and daily appointments).	Health records
<i>Reports</i>	Allows the running of different types of report for patient records in the system to aid decision making.	List of reports (e.g. number of registered patients, number of completed forms and number of visits/encounters).	All service points (based on user-assigned views and privileges)
<i>System Administration</i>	Supports the configuration of modules, forms and other system settings.		All service points (based on user-assigned views and privileges)
<i>ANC Form</i>	Allows midwives/nurses (or HIOs or their scribes) to enter details of ANC visits of pregnant mothers.	ANC patient information (e.g. ANC visit, mother's medical information, family history, previous pregnancies, investigations, HIV)	Mother and child

¹ There are two registration points because Festac PHC operates a decentralised system where the mother and child clinic and the outpatient clinic register patients separately but only combine reports for monitoring and evaluation purpose.

² This module was not implemented for Festac PHC because patients do not need to book for an appointment before attending the clinic. The clinic hopes to use this feature in the future.

		information, vaccination schedule, ANC examination/vitals and next appointment).	
<i>Immunisation Form</i>	Allows midwives/nurses (or HIOs or their scribes) to enter details of immunisation of children (under 5).	Immunisation data (e.g. visit summary, vaccine name and batch number, date given, provider name and date of next vaccination).	Mother and child
<i>Visit Note</i>	Enables the doctors (or their scribes) to enter patient complaints, diagnoses, prescription and test orders.	Visit details (e.g. presumed/confirmed diagnosis, primary and secondary diagnoses, provider name, location, date of visit and clinical note/complaints)	Consultation

5.6.3 EHR setup/configuration

As mentioned in [Section 4.6.1](#), the main technical components of OpenMRS configured are the database (data concepts mapping, backups, security, etc.) and the EHR software (clinical modules and customisations). The study initially designed a cloud solution before the implementation but changed to a local area network (LAN) design due to poor internet access in the health facility. The equipment included laptops, a desktop PC (dedicated server), networking (16-ports Ethernet switch, wireless router, Cat 6 cables and RJ45 connectors), power inverter (to provide power for the server when electricity from national grid and generator set is unavailable) and printer.

5.6.4 System evaluation results

Following the user survey conducted ([Section 4.6.2](#)), there was a consensus by the 7 healthcare professionals (HCPs) who completed the EHR user survey that the system was not difficult to use. See Appendix 8 for details.

5.7 EHR interoperability

Interoperability has attracted several definitions over time across different domains. In the healthcare domain, the concept can be defined as *"the ability of different information systems, devices and applications ('systems') to access, exchange, integrate and cooperatively use data in a coordinated manner, within and across organisational,*

regional and national boundaries, to provide timely and seamless portability of information and optimise the health of individuals and populations globally" (HIMSS, 2021). Recent studies note that the exchange of captured data via information systems in the health domain can be difficult due to the complex nature of health and social care processes (Johnson, Kamineni, Fuller, Olmstead, & Wernli, 2014).

Typically, an interoperable EHR (as described in [Section 1.10](#)) can attain different levels – foundational, structural, semantic and organisational (HIMSS, 2021). At the foundation level, the EHR can seamlessly exchange data with another EHR system. The structural level interoperability entails uniform specification for data being exchanged to allow different EHRs to process it. Examples of structural interoperability specifications include data representation formats such as JSON, XML and CSV, data element types, syntax, and message protocols. The semantic level involves ensuring a shared understanding and meaning of clinical concepts in the data being exchanged. Clinical concepts can be loosely described as subject headings for various clinical resources (e.g., date of birth in patient demographics, diagnosis codes and text descriptions). Table 20 illustrates the layers of data modelling and the associated modelling tasks.

Table 20: Abstraction layers for modelling data across MCH services

Layers	Key terms	Typical tasks
Knowledge	Pathway (post-it notes, child care pathway) Guideline Ontology / Knowledge objects (KO) Value sets	Visualise health information exchange for analysis/planning purposes, Produce interoperability reports,
Information	CodeSystem / ConceptMap Terminologies/ Vocabularies (e.g. CIEL, ICD-X, SNOMED CT, LOINC, RxNorm) Standards (e.g. FHIR, OpenEHR)	Coding clinical concepts, Mapping, Content authoring, Develop value sets, applications with programming languages, e.g. Java, C#
Data	Models (e.g. attributes, relationships and cardinalities) Sets Items Types/Elements	Design models, Create database structures

Prior studies note that clinical concepts often vary from one EHR to another either due to the lack of standards for subject headings used to describe clinical resources or customisations introduced during implementations. The differences in subject headings also introduce ambiguity in a way that makes semantic interoperability challenging or impossible. For example, a primary care facility can send a patient summary printed from its EHR system to a specialist in a secondary/tertiary care setting via fax, paper notes or electronically. The data is keyed into the receiving EHR but without the system having a grasp of how the sender EHR represented the clinical concepts. When this happens, it raises inconsistent clinical data exchange, which could result in poor clinical outcomes.

At the organisational level, achieving interoperability across EHRs is a crucial factor in deriving the benefits of using EHRs in healthcare. As such, there appears to be a growing number of developmental efforts by standards development organisations (SDOs) such as Health Level Seven International (HL7) (HL7, 2021), SNOMED International (SNOMED International, 2021) and CDISC (Clinical Data Interchange Standards Consortium, 2020) aimed at providing platforms and standards like (e.g. FHIR and OpenEHR) to support health institutions in achieving the various levels of interoperability locally, regionally and nationally (Sansone & Rocca-Serra, 2016).

5.8 Workshop findings from the MedInfo 2019 Conference

5.8.1 Workshop overview

As part of this study, a workshop of domain experts in EHR implementation and health IT managers was organised. The workshop's aim, also described in [Section 4.5.3](#), was to identify critical barriers to achieving interoperability, priorities for new implementations and lessons learned from managing existing EHR implementations. The workshop was held as part of the MEDINFO 2019 Conference in Lyon, under the track: *"Supporting Care Delivery: Electronic Health Records"*. Twenty participants from various institutions attended the session, including:

- AUT, New Zealand (1)
- Brown University, US (1)
- Harvard Medical School, US (1)
- Partners In Health (PIH), US (2)
- University of Oxford, UK (1)
- University of Portsmouth, UK (2)
- VA Veterans Health Administration, US (1)
- World Health Organisation (WHO), Switzerland (2)
- Other institutions (9)

The session was jointly chaired by the author, Dr Hamish Fraser, and Dr Philip Scott. The author is a PhD student in health informatics and recently implemented EHR in an LMIC setting. Hamish is a health informatics expert with over 20 years of experience in health informatics, co-founder of OpenMRS (EHR application) and has been involved in the roll-out of EHR implementations in LMIC countries. Philip is a Reader in health informatics with over 18 years of experience in healthcare IT development in HICs.

5.8.2 Group discussion

Much of the conversation in the workshop centred around the earlier questions posed in [Section 4.5.3](#), findings from the pilot study at Festac PHC and how the theory of change (ToC) approach could be used to foster interoperability of EHRs, especially in LMICs. Of the many themes presented, most participants reacted to data modelling and the adoption of a centralised EHR architecture.

Participants stressed the vital role of data models and their adoption across EHR implementations. Data models were identified as essential preconditions to achieving effective communication exchange between digital health systems in LMICs, which is needed to realise the benefits of EHR implementations.

However, participants also noted many available models with differences in data element specifications, clinical concepts, relationships, and representation formats. For

example, one contributor stated that *"there are no centralised data models for most EHR implementations"*. Another participant shared a list (see Figure 17) showing the variation of ANC concepts in separate EHR systems in two LMIC countries – Nigeria and Zimbabwe, both using OpenMRS. Many suggested that the variations were attributed to the ambiguity in healthcare delivery. The variations in specifications for multiple EMR implementations across LMICs make it challenging to have standard coherent data dictionaries. These realities are not just peculiar to LMICs, but health systems in HICs face the same challenge.

4	NIGERIA	ZIMBABWE	29	Hep B	Hepatitis B Screen
5	ANC Visit	Number of Prenatal Clinic Visits	30	VDRL - Woman	Syphilis Screen
6	Serial Number		31	VDRL - partner	
7	<i>Mother's Medical Information</i>		32	RV/HIV	HIV Screen
8	Gravida	Gravida	33	Ultrasound 1	Ultrasound Scan to Determine Gestational Age
9	ANC 1 Timing	Number of Prenatal Clinic Visits	34	Ultrasound 1 Date	
10	Previous Illness	Medical and Surgical Illness	35	Ultrasound 2	Ultrasound Screen for Structural Abnormalities
11	Parity	Parity	36	Ultrasound 2 Date	
12	Infertility		37	Haemoglobin PCV	Haemoglobin Status
13	Previous Surgery	Medical and Surgical Illness	38	Other Investigations	Rubella Susceptibility
14	Expected Date of Delivery	Gestation Age	39		
15	Recent Family Planning Method Used	Contraception	40	HIV Information	
16	Blood Transfusion		41	<i>Vaccination Schedule</i>	
17	IMP		42	Tetanus Dose	Anti-Tetanus Toxoid
18	Allergies		43	Tetanus Date	
19	Medications		44	IPT Dose	
20	<i>Family History</i>		45	IPT Date	
21	<i>Previous Pregnancies</i>		46	Instructions/Remarks	
22	Date of Birth	DOB	47	<i>ANC Examination</i>	
23			48	Weight	Height
24	Investigations		49	Height	Weight
25	Blood Group Father		50	Temperature	BMI
26	Genotype Father		51	Systolic BP	Blood Pressure Reading
27	Blood Group Mother	Blood Group and Rhesus D status			

Figure 17: Mapping datasets from ANC and delivery applications using CIEL/OCL on OpenMRS

The most mentioned data models that support interoperability across health systems include OpenEHR and FHIR. OpenEHR is a concrete model used to represent clinical data concepts in EHRs in archetypes specific to each health facility. On the other hand, FHIR is an abstract model used for sharing data between different EHRs and involves exchanging HL7 messages across health facilities. According to the participants, it has been difficult for countries to adopt one as the standard framework for health data exchange across hospitals. For countries like the UK, there appears to be a gradual move towards adopting FHIR as the framework for health data interoperability across England, Scotland, Wales and Northern Ireland. Also, it has been noted that either FHIR or OpenEHR provides a platform for diverse stakeholder communities to use standardised data and concepts in developing health IT applications.

Another theme closely related to data modelling that was discussed is concept mapping. Data is not usually captured in healthcare facilities using any of the interoperable data models discussed so far. To exchange captured data with other healthcare institutions or EHR applications, clinical coders or other health professionals with prerequisite knowledge manually map data to the respective data models using standardised vocabularies. Participants agreed that it takes much time to code clinical concepts with Columbia International eHealth Laboratory (CIEL) dictionary. It also takes time to map those concepts to terminologies such as SNOMED CT before getting the data items ready for exchange using the health institutions' agreed interoperable common data model (CDM). Some participants suggested using interoperable CDMs as the specifications for capturing data during routine health care practice. However, implementing and maintaining CDMs could be time-consuming and require accessible expertise, training and effective documentation (Kahn, Batson, & Schilling, 2012; Scott & Heitmann, 2018).

Furthermore, a recurring theme is summarised in the quotation: *"health institutions do not want to share their data models, especially in the US"*. Not only are people reluctant to share their data, but they are also reluctant even to share their data structures owing to perceived consequences in doing so. Nevertheless, one participant described how OpenMRS is being used to encourage the sharing of maternal concepts in low- and middle-income countries (LMICs). Examples are Uganda, Kenya and Ethiopia, where clinical concepts are shared through the Open Concept Lab (OCL), formerly Maternal Concept Lab.

Similarly, another theme discussed was the need for a national digital health system or a centralised registry for maternal health. According to participants, there is no established centralised registry for maternal health in LMICs. However, there are some examples of national eHealth systems such as Chile, Columbia and Ethiopia. Although Nigeria has a national health ICT framework (Federal Ministry of Health, 2016), there is no national EHR implementation or agenda (Ebenso et al., 2018; Odekunle et al., 2017). It would be worth eliciting other developing countries' experiences that have gone

ahead with centralised implementation or specification to gauge the workability of such an approach.

Other themes discussed include top-down vs bottom-up approach to standards design, data reporting techniques for modelling MCH services, managing datasets (neonatal datasets, standardised data collection at an operational level, Maternity Services Data Set, NHS UK through Maternity Record Standards (Professional Record Standards Board, 2019) and the role of IT in fostering community practice.

5.8.3 Drivers for implementing an interoperable EHR

Drivers for an interoperable EHR differ between LMICs and high-income countries (HICs). For example, LMICs focus mainly on aggregate data from the health information system for disease control, population health monitoring and health policy and planning. Moreover, funders use the aggregate data to drive health financing and, in some cases, to fund EMR implementations. HICs pay more attention to the quality of care, continuity of care and precision medicine. Nevertheless, there was a consensus on increased funding for infrastructure required to assure successful EHR implementation in LMICs.

5.8.4 Preconditions

Based on the conversations had, we identified the following preconditions for achieving interoperability across EHRs in LMICs:

1. National identifier for patients/citizens
2. Incentives for EHR from the government for health institutions
3. Infrastructure – funding partners, vendors, insurance companies, pension funds can support the government (e.g. the Ministry of Health)

5.8.5 Discussion and summary findings

The workshop highlighted that data modelling and interoperability standards are vital priorities for maternal and child health data services in LMICs. Data models are crucial

to realising effective communication exchange across digital health systems. There are some common interoperability standards for MCH like Fast Healthcare Interoperability Resources (FHIR) and OpenEHR available for LMICs to use. It is also possible for EHRs implementations such as the pilot EHR study in Festac PHC. Data modelling/sharing issues may not surface when using EMR because the electronic system is designed for a specific purpose (act as data capture and storage system). However, as the project matures, increases in scope, locations and partners, the lack of attention to interoperability could negatively impact the project's viability (Kahn et al., 2012). Hence, it is vital to ensure a robust standardisation to collect and share data at all levels.

The following summary points were the reflections from the exploratory workshop:

- Data models are vital to realising effective data exchange between digital health systems by adopting the appropriate interoperability standards for MCH.
- Drivers for an interoperable EHR differ between LMICs and high-income countries (HICs).
- Adequate infrastructure and accountable funding are essential preconditions needed for any sustainable EHR implementation.
- Toolkits such as ToC are essential in shaping the EHR implementations for maternal and child healthcare services.

5.9 Document analysis findings

This section provides detailed findings following the descriptions in Subsections 4.5.3 and 4.5.4. Although the findings of the document analysis are spread across this report, the characteristics, data analysed, and location of the 15 selected documents are represented in Table 21—eleven of the selected documents focused on health contexts in Nigeria and LMICs. Four documents examined developed or generic contexts. A majority of the document types are reports (n=7) prepared for governmental and non-profit sectors. Other document types include health indicators (n=2), strategic plans (n=2), guidance documents (n=2), an official gazette (n=1) and a case study (n=1). The extracted themes centred on strengthening health systems, digital health and Theory of

Change. The analysed data is mixed and ranges from definitions of concepts to challenges facing systems and from health indicators to guidance on implementations. Despite the spread of qualitative findings across the study chapters, no documents were reviewed for the literature review, methodology and conclusion chapters. In the literature review chapter, grey literature (documents) were not a part of the included studies because they do not meet the requirements of peer-reviewed studies. Research methods textbooks were mainly consulted to inform the research design in the methodology chapter. The conclusion chapter was a derivative of the preceding chapters; hence, referencing documents was irrelevant.

Table 21: Document analysis based on characteristics, themes, data analysed and location in the study

Documents selected (and sources)	Document type	Themes	Data analysed	Location in this study
Research for universal health coverage (Dye et al., 2013, World Health Organisation)	Report	Health for all, Health financing, poverty, diseases, low- and middle-income countries (LMICs).	Challenges faced by health systems in LMICs.	Section 1.1
Health at a Glance 2015: OECD Indicators (OECD, 2015)	Health indicators	Health status, access to care, quality of care, healthcare activities, health expenditure and financing.	Challenges of health systems in high-income countries.	Section 1.1
National Strategic Health Development Plan II (2018 - 2022) (Federal Government of Nigeria, 2018)	Strategic health development plan	Health priorities, healthcare system, access to quality care, strategic pillars, healthcare costs.	Structure of the Nigerian healthcare system.	Section 1.5
National Health Act, 2014 (Federal Republic of Nigeria, 2014)	Statute (Official gazette)	Responsibility for health, health establishments and technologies, healthcare personnel, health research.	Assignment of responsibilities of the Nigerian health system to the 3 tiers of government.	Section 1.5
Nigeria Demographic Health Survey 2018 (National Population Commission (NPC) [Nigeria], & ICF, 2019)	Health indicators	Maternal and child health, health survey, sustainable development goal	Data on maternal and child mortalities in Nigeria.	Section 1.6
Levels & trends in child mortality report 2018 (United Nations Children's Fund, 2018)	Report	Under-five mortality, neonatal mortality, global health	Data on maternal and child mortalities globally.	Section 1.6
Primary health care systems (PRIMASYS): case study from Nigeria (World Health Organisation, 2017)	Case study	Primary healthcare, health financing, LMICs, maternal and child health	Data on maternal and child mortalities in Nigeria.	Section 1.6
National Health ICT Strategic Framework 2015 - 2020 (Federal Ministry of Health, 2016)	Strategic e-health plan	Information and Communication Technology (ICT), health ICT roadmap, monitoring and evaluation (M&E), Enabling environment.	Gaps and implications of the Nigerian health ICT strategy for digital health implementation.	Sections 1.7, 5.8 & 6.3
Spending to Save: Challenges and Opportunities for Financing Nigeria's Saving One Million Lives Initiative (Results for Development Institute, 2014)	Report	Health and public financing, essential medicines, immunisation, malaria, nutrition, MCH, prevention of mother-to-child transmission of HIV.	Goal of the Saving One Million Lives (SOML) initiative.	Section 1.7.4

Assessing the enabling environment for ICTs for health in Nigeria: a landscape and inventory (United Nations Foundation, 2014)	Report	SOML, ICT4SOML, ICT for health landscape, inventory, health status, MCH.	Assessment of ICT for Health in Nigeria including 84 digital health implementations.	Section 1.7.4
Review of the use of 'Theory of Change' in international development (Vogel, 2012, Department for International Development)	Report	Theory of Change, international development, ToC elements, implementation, evaluation.	Definition of Theory of Change.	Sections 3.2, 4.3.3
Theory of Change Technical Papers: A series of papers to support development of theories of change based on practice in the field (Taplin et al., 2013, ActKnowledge)	Technical paper	Theory of Change, programme logic, monitoring and evaluation, long-term outcomes, assumptions.	Understanding the theory of change (ToC) process.	Section 3.2.2
Monitoring and evaluating digital health interventions: a practical guide to conducting research and assessment (World Health Organisation, 2016)	Guide	Digital health interventions, monitoring, evaluation, data sources.	Examining various evaluation frameworks to support digital health implementations.	Section 3.3
Interoperability Standards - Digital Objects in Their Own Right. (Sansone & Rocca-Serra, 2016, Wellcome Trust)	Report	Interoperability, standardisation, digital objects, FAIR (Findable, Accessible, Interoperable and Reusable).	Development of standards to help health institutions to achieve different levels of interoperability.	Section 5.7
Adapting the EHR Scribe Model to Community Health Centers: The Experience of Shasta Community Health Center's Pilot (Howard et al., 2012, InformingChange)	Evaluation report	Scribe model, EHR, Clinician satisfaction, patient satisfaction.	Exploring EHR data capture using the scribe model.	Section 6.4

5.10 Generic Theory of Change

The generic ToC (Figure 18) theorise that the long-term goal of the EHR implementation study is to improve maternal and child healthcare delivery with optimised EHR based on the assumption that sustainability factors are thought through and measures are put in place to achieve this goal.

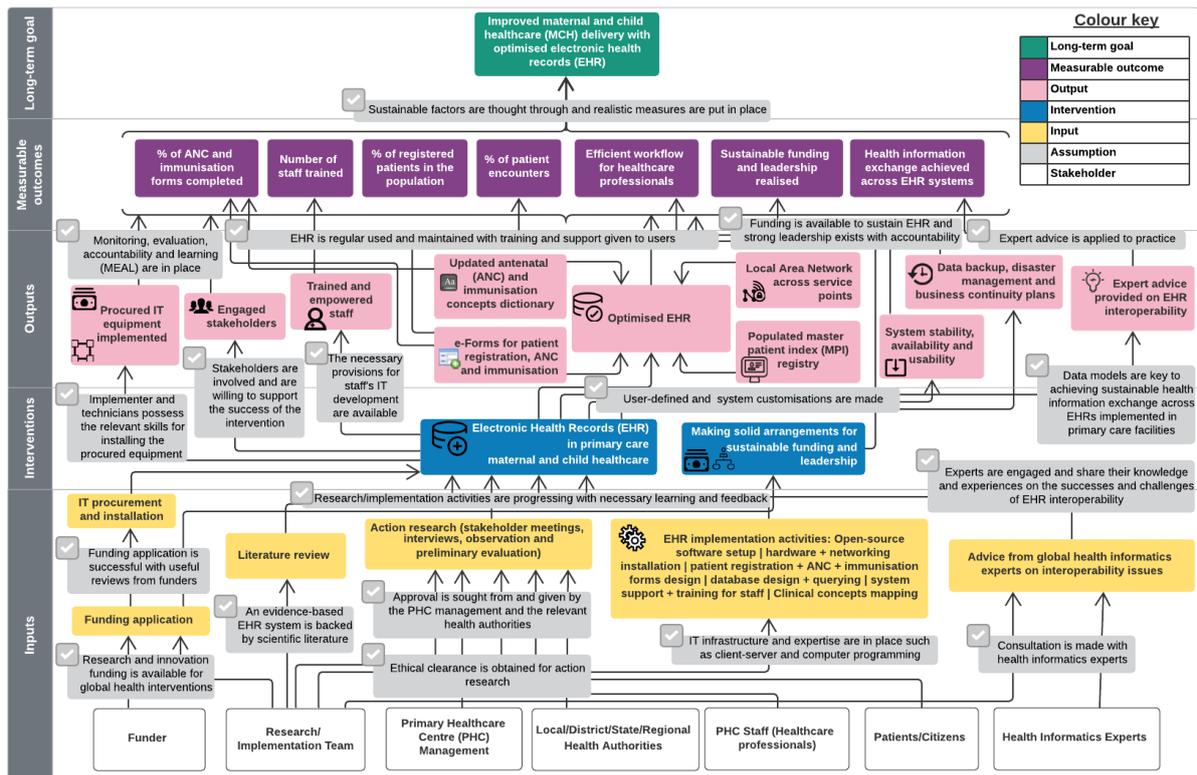


Figure 18: A generic version of Theory of Change for Electronic Health Records implementation, without context-specific details

5.11 Chapter summary

The following are the summary of findings from the primary research:

- The ToC identified real changes during the pilot study. The EHR adoption and usage data from the system go-live revealed that the number of registered patients and patient registration forms completed on the EHR system was 1790. ANC and immunisation encounter forms (n=198 and n=309) were completed. Vital signs (n=325) and visit notes (n=177) were entered into the EHR.
- The main technical components of OpenMRS are the database (data concepts mapping, backups, security, etc.) and the EHR software (clinical modules and customisations).
- The interview data (n=14) showed that the EHR implementation was relevant and identified key themes relating to readiness, expectations and sustainability of the EHR implementation.
- There was a consensus by the 7 healthcare professionals (HCPs) who completed the EHR user survey that the system was not difficult to use.
- The workshop highlighted that data models are crucial to realising effective communication exchange across digital health systems by adopting the appropriate interoperability standards for MCH with common data models.
- The document analysis showed the relevance of the 15 selected grey literature in providing contextual information across the study.
- The study proposed a generic ToC map that can be used by LMIC implementers to introduce an optimised EHR with the assumptions about sustainability and other relevant factors.
- The critical success factors were the sustainability, financial and organisational categories. The PHC management and the research team agreed on solid arrangements to ensure that the EHR implementation is sustained, but there was no guarantee with arrangements.

Chapter 6: Discussion

6.1 Overview

This chapter critically discusses the findings of the study. [Section 6.2](#) emphasises the value of the Theory of Change (ToC) process. [Section 6.3](#) critically evaluated the study objectives and the findings. [Section 6.4](#) provides that reflections on real-world experience. [Section 6.5](#) highlights the study limitations.

6.2 Theory of Change for digital health implementation in LMICs

This study shows the value of the ToC process for robust planning, analysis and evaluation of the EHR implementation complexities and challenging the assumptions of all stakeholders. The process requires logical reasoning, effectively engaging stakeholders in drawing implicit assumptions, designing the preconditions and mapping backwards from the long-term goal to inputs. Political factors play a role in influencing what practitioners say about their beliefs/theories on the desired change. The practitioners may have concerns about the management disapproval of their assumptions (Weiss, 1997). For example, HCPs were asked about the leadership style of their line managers and the effect of that on their use of EHR. Most of the HCPs made positive comments about their managers. Although it is possible to have all positive feedback about leadership styles in a typical work setting, the lack of concerns or negative comments may suggest desirability bias or groupthink (King & Crewe, 2013).

ToC is useful in articulating assumptions made about a programme or intervention to achieve its desired results. The study generated assumptions from peer-reviewed evidence (documents and prior research), experience and views of practitioners and other stakeholders – funder, government, policymakers and logical reasoning (Table 16). However, it can be problematic to test the assumptions even when they are explicitly stated. Problems such as measurement, generalisation and validation usually plague programme theory (Weiss, 1995).

Again, the ToC approach is particularly useful in capturing the complexities of a programme relating to its outcomes, outputs, inputs, and activities to bring about a long-term change by employing relevant interventions (Chibanda, Verhey, Munetsi, Cowan, & Lund, 2016). The relevant stakeholders were engaged by getting them to share their experiences and practices (explicit assumptions). Implicit assumptions, which were not obvious to the practitioners and experts, were drawn out through interviews and a user survey. Those assumptions were modelled and combined with evidence and logic. All of these were put together in readiness to transmute into practice.

6.3 Critical evaluation against research questions

Table 22 shows how each research question has been answered with the study.

Table 22: Overview of the study questions and rationales

	Research question (RQ)	Rationale
RQ #1	How can electronic health records (EHR) effectively benefit the delivery of maternal and child healthcare (MCH) in Nigeria?	The literature review (Chapter 2) identified the gaps relating to the limited evidence on EHR effectiveness for MCH in Nigeria. The Theory of Change (Chapter 5) demonstrated the following benefits: reduced costs of paper processes, easier clinical audit, efficient workflow for healthcare professionals and EHR as a foundation for interoperability.
RQ #2	What are the sustainable factors of digital health implementation for maternal and child healthcare, learning from experiences in developing and developed nations?	ToC, through the qualitative analysis and selected success criteria (Sections 5.5, 6.3 and 6.4), identified appropriate funding, accountability and a firm commitment from the management as factors for a sustainable digital health implementation.
RQ #3	What are the priorities, preconditions and barriers to implementing an interoperable EHR in low- and middle-income countries?	ToC, through the workshop, highlighted data models as a priority; funding and infrastructure as preconditions for interoperable EHR (Sections 5.7 and 5.8).

Furthermore, the study findings were evaluated by a summary of the key successes and lessons learned alongside the study's implications. Table 23 provides an extensive evaluation of the EHR implementation using seasoned success criteria described in [Section 4.3.4](#) (Deriel et al., 2018; Fritz et al., 2015).

Table 23: Summary of successes, lessons learned from the pilot study in Festac PHC and implications for EHR implementations in Nigeria and other LMICs

Categories	Key case study successes	Lessons learned and implications
Ethical	<p>The Nigeria Data Protection Regulation (NDPR) 2019 guidelines were enacted into law at the time of this study. This study complied carefully with the General Data Protection Regulation (GDPR) 2016 guidelines as applicable within the UK.</p> <p>Login credentials were created for all users across departments, and unauthorised access was prevented. This measure ensured the security of patient records in terms of privacy and confidentiality.</p>	<p>The concept of ownership of data for patients is not widely appreciated.</p>
Political	<p>The EHR implementation fits into the vision of the National Health ICT framework for Nigeria, which states that “by 2020, Health ICT will help enable and deliver Universal Health Coverage” (Federal Ministry of Health, 2016).</p> <p>The local authority bought into the project and provided relevant support needed to progress the implementation without any interference from political figures.</p>	<p>The local authority delayed in granting approval for the study due to the number of persons needed to sign the permission request. The primary contact from the PHC made efforts in getting the paperwork to go through all the relevant parties. It is vital to build informal relationships and maintain communication with reliable local contacts, particularly the ones that are keen about the digital health transformation agenda. Sometimes, this approach works differently in developing and developed countries.</p>
Organisational	<p>The management of the Festac PHC granted the necessary approval to the research team to commence the pilot study.</p> <p>The health professionals, especially the head of nursing and health information officers (HIOs), showed significant commitment to adopting the EHR system.</p> <p>Efficient workflow for health professionals.</p>	<p>Certain physicians and midwives were not willing to use the EHR initially until they were persuaded or incentivised by the management. The clinicians perceive the EHR use will add to their ever-busy workload, and the issue of staff shortage is present. Although the benefits of EHR were visible, it was hard for the head of units to convince the clinicians to use the EHR.</p> <p>It was challenging to go fully electronic; hence the health information officers maintained both paper and electronic records until they were confident that the patient records matched both formats.</p>
Financial	<p>Secured funding for the feasibility study.</p> <p>Procured the IT equipment including servers, laptops and networking.</p> <p>Reduction of cost of IT infrastructure that the Festac PHC would have incurred.</p>	<p>The initial cost of implementation was high, and funds mainly came from the funding partner. Supplementary funding from the local authority directing Festac PHC would have significantly moved the project forward. For example, suitable financing would have enabled the purchase of additional laptops for the consulting rooms, immunisation points, laboratory and pharmacy. Access to the EHR system with the required infrastructure by all service points during patient visit will ensure completeness of records for proper reporting and improved delivery of patient care. Moreover, additional funds could have been used to pay for a continuous broadband subscription, which would have enabled remote technical support for the EHR.</p>
Functionality	<p>Implementation of patient registration, outpatient, laboratory and reports modules.</p> <p>ANC and immunisation e-forms were designed efficiently to encourage data entry by HIOs.</p> <p>Easier clinical audit tracking for antenatal care and immunisation of patients.</p>	<p>UgandaEMR’s ANC and immunisation e-forms were adapted instead of reinventing the wheel, which saved development time. The ANC concepts differ between Nigeria and Uganda; hence, the expertise of the M & E officer and the midwives was consulted to understand the concepts, which helped in successfully coding them in the EHR.</p>

EHR has helped Festac PHC to keep more complete records of patients/citizens.

Technical

Local area network (LAN) design was implemented across service points in the PHC.
Enterprise edition of OpenMRS was successfully installed using a WAR (Web Application Resource) file.

JavaScript was used to optimise the e-forms (hide and show content) to encourage efficient data entry for HIOs and to reduce the boredom of scrolling through lengthy webpages each time ANC and immunisation records are entered.

The initial cloud design halted due to poor internet access (4G) on the clinical site. Moreover, there was a lack of commitment to funding wireless subscriptions beyond the amount budgeted. Future implementations need to have an alternative network design plan of which wired LAN connection proves to be the most reliable.

There were compatibility issues with Java Runtime Environment (JRE), MYSQL server and Apache Tomcat. These issues took about 3 days to resolve until the compatible versions were identified. Future implementers need to be aware of potential compatibility issues with software applications before implementation and at the same time, to be tenacious/dedicated because it can be a discouraging experience especially when the expectations are high for a timely implementation delivery.

Training

Clinical staff were trained to use digital health.
Technical support was provided for the period of and shortly after the implementation.

Health practitioners could not continue to support the EHR system because there was no technical staff on the ground. The lack of technical support affected the smooth running of the system, and the clinicians were left at the mercy of the busy implementer. Provisions should be made by the PHC management for a periodic staff training and system support to ensure the continuous staff development and effective running of the EHR, post-implementation.

Sustainability

Implementation of a wired LAN architecture in the health facility so that there is local networking for the different client locations to access the server.
Internet connectivity for 12 months to support data backup, synchronisation, clinical research, reporting and remote support for the EHR system.
Installation of a 1 KVA power inverter with a 200 ampere hour battery to run the server for 10 hours in the absence of electricity from the national grid and generator.
Purchase of laptops with a battery life of 6 hours for operations such as data entry.
Implementation of a routine backup of the database containing patient records.
Handed over formally to the monitoring and evaluation officer (M & E, primary contact for the PHC) with a letter containing the list of equipment and signatures of relevant stakeholders. This formality was done to ensure that the equipment is sustained, although not guaranteed.

The M & E officer was transferred to another PHC 6 months after the implementation. This staff movement created a knowledge gap in maintaining the system.

The funding stopped, but the PHC management did not continue with the financing. Hence, there should be a firm commitment from the local authority to provide supplementary funding for the operation and maintenance of the EHR, especially before the project initiation and after the implementation.

Some benefits/improvements were sustained, including training, change of mindsets from paper to electronic records and continuous usage of the equipment beyond the project lifetime for aggregate data collection.

6.4 Pragmatic reflections on real-world experiences

6.4.1 Reflections based on experiences from other low- and middle-income countries

Despite Festac PHC being an early adopter of EHR and the only one among other public PHCs in Lagos State, the management can fund such an infrastructure and ensure its sustainability. The issue of funding and other EHR implementation challenges are not peculiar to the Nigerian context, but they apply to different LMIC contexts (Deriel et al., 2018; Muinga et al., 2018; Oza et al., 2017). Table 24 compares findings from OpenMRS implementations in three developing countries (Nigeria, Sierra Leone and Kenya) – inclusive of this study (Festac PHC, Nigeria). Common findings across the three studies related to data collection, staff training and infrastructure. These studies showed EHR usage results in clinical workflow efficiencies. At the same time, the studies discussed the challenges encountered during implementation, which centred mainly on inadequate infrastructure, funding, dedicated IT support and stakeholder buy-in. One significant issue across the three EHR implementations is sustainability, and the Nigerian (Festac PHC) study used the ToC approach to underscore this issue extensively. Despite their successful completion, the implementations did not continue beyond the first or second phase. Hence, stakeholders must pay close attention to sustainability issues before embarking on EHR implementations in LMICs.

Table 24: A comparison of EHR implementation findings from three low- and middle-income countries

	Nigeria (This study)	Sierra Leone (Oza et al., 2017)	Kenya (Muinga et al., 2018)
Year of implementation	2019	2015	2014
Location/Site	Festac Primary Health Centre (PHC), Festac Town, Lagos	Ebola Treatment Centre (ETC), Kerry Town	Public hospitals (county referral hospital and health centres in Machakos and Baringo Counties)
Aim/Objectives	<ul style="list-style-type: none"> To develop a theory of change (ToC) to assess the feasibility of EHR implementation for the delivery of maternal and child health (MCH) in low- and middle-income countries (LMICs). 	<ul style="list-style-type: none"> To rapidly develop OpenMRS-Ebola, an open-source Ebola EHR system that was implemented in 2015 at Save the Children's Kerry Town ETC in Sierra Leone. To describe the experiences, lessons learned, and recommendations for design and implementation of EHRs in future health emergencies. 	<ul style="list-style-type: none"> To present a descriptive case study of the implementation of an open source electronic health record system in public health care facilities in Kenya.
Methodology	<ul style="list-style-type: none"> Applied the ToC approach Adapted some success factors to supplement the ToC approach in evaluating the maturity of the EHR implementation 	<p>Four-component strategy:</p> <ul style="list-style-type: none"> Agile software methodology; Recruited team members with diverse skills and experience; Iterative design based on usability, speed, and clinical needs; and Regular communication and feedback between the operations and development teams. 	<p>Conducted:</p> <ul style="list-style-type: none"> A landscape review of existing literature concerning eHealth policies and electronic health record development in Kenya. Informal discussions with the Ministry of Health, the World Health Organization, and implementing partners A series of visits to implementing sites Semi structured individual interviews and group discussions with stakeholders to produce a historical case study of the implementation.
Software	OpenMRS	OpenMRS-Ebola	OpenMRS
Hardware	Laptops, server, generators, power supply inverter	Solar-charged tablets, laptops, Servers, generators	Laptops, zero clients (all-in-one computer terminals), server, solar power, generators,
Networking	Wired network	Wireless network	Wired and wireless network
Scale (pilot/at scale)	Pilot	Emergency/Crisis	At scale
Project completion	Phase 1 completed	Phase 1 and 2 completed. Phase 3 partially completed (not deployed)	Phase 1 and 2 completed

Programme (MCH, Ebola)	Maternal and child health, Essential primary care services (outpatient clinic, pharmacy and laboratory)	Ebola	Maternal and child health, Essential primary and secondary care services (outpatient, pharmacy, laboratory, inpatient, specialized clinics and community health system)
Level of care (Primary/Secondary)	Primary	Primary/Secondary (Treatment centre)	Secondary (Phase 1), Primary (Phase 2) due to scaling back.
Key findings	<p><i>Theory of Change:</i> 3 ToC maps, 1790 patients were registered, 198 ANC and 309 immunisation e-forms were completed, 325 vital signs and 177 visit notes were entered into the EHR</p> <p><i>Ethical:</i> Login credentials were created for all 20 users across departments, and unauthorised access was prevented</p> <p><i>Political:</i> Local authority buy-in</p> <p><i>Organisational:</i> Management and staff buy-in,</p> <p><i>Financial:</i> Procured the IT equipment including 1 server, 10 laptops and networking</p> <p><i>Functionality:</i> Implemented patient registration, outpatient, laboratory and reports modules; designed ANC and immunisation e-forms</p> <p><i>Technical:</i> Local area network (LAN) design was implemented across service points in the PHC.</p> <p><i>Training:</i> 14 clinical staff were trained to use EHR, technical support</p> <p><i>Sustainability:</i> Internet connectivity for 12 months to support data backup, formal handover of equipment with letter of agreement for sustainability</p>	<p>Training: 100 clinicians were trained</p> <p>Estimated cost: \$187,000</p> <p>System usage:</p> <ul style="list-style-type: none"> • 112 patients were registered • 569 prescription orders were placed • 971 medication administrations were recorded <p>Paper records:</p> <ul style="list-style-type: none"> • 15 errors during patient registration • 553 of 569 prescription orders correctly matched 	<p><i>System (infrastructure):</i> 15 laptops, 1 central server, 5 IT staff, 4 IT interns and 1 software support company.</p> <p><i>People:</i> Trained staff in 4 health facilities</p> <p><i>Process:</i> Data entry, accuracy and integrity done by clerks.</p> <p><i>Products:</i> optimised software modules including patient registration, outpatient, inpatient, laboratory, pharmacy, health records and hospital inventory</p>
Notable challenges	<p><i>Ethical:</i> No data ownership for patients</p> <p><i>Political:</i> Approval delay from local authority</p> <p><i>Organisational:</i> Clinicians not willing to use EHR</p> <p><i>Financial:</i> Initial cost of implementation was high, and funds mainly came from the funding partner</p> <p><i>Functionality:</i> Lengthy ANC and immunisation e-forms</p> <p><i>Technical:</i> Poor internet connectivity, Software compatibility issues</p> <p><i>Training:</i> No dedicated technical support</p> <p><i>Sustainability:</i> Main EHR champion was transferred to another PHC, funding stopped</p>	<p>Inadequate training due to limited time.</p> <p>Staff issues relating to the availability of skilled personnel, e.g. IT support.</p> <p>Incomplete evaluation.</p> <p>Power outages</p> <p>Poor network connectivity</p> <p>Damaging equipment</p> <p>EHR could not fully replace paper system</p> <p>Using both paper and electronic records</p> <p>Cost of implementation</p>	<p><i>System (infrastructure):</i> Poor electricity, inadequate hardware, equipment theft and networking</p> <p><i>People:</i> Low levels of computer literacy, reported high user workload, limited support staff, lack of user buy-in, training barriers due to varying staff schedules</p> <p><i>Process:</i> Commissioning of a major project resulted in a shift of attention and resources</p> <p><i>Products:</i> Request for additional functionality, comprehensive testing needed to ascertain whether all changes requested were captured</p>

6.4.2 Reflections based on experiences from high-income countries

Policymakers and politicians in LMICs can learn from countries that incentivised EHR adoption by providing implementation funds to health facilities. A prime example is the UK, where the EHR adoption rate in primary care, particularly general practitioners' (GPs) practices, is nearly 100% (Benson, 2002; Schade, Sullivan, de Lusignan, & Madeley, 2006). Among other factors, financial incentives from the government have proven to be an effective impetus for EHR implementation across GP practices. For many years, thought leaders in the GP profession have collaborated with the government to provide incentives for digitising practices and eliminating barriers. Hence, GPs were more willing to use EHRs than hospital doctors, helping the former leverage the successful health IT intervention (Benson, 2002). Despite the successful EHR adoption rate by GP practices in the UK, the system has its shortcomings. The system sometimes fails as patients show up at the community pharmacy expecting to pick up medication, whereas the electronic prescription has not reflected on the pharmacy system. This issue can often delay treatment for patients as the pharmacy team chases prescriptions on weekends when GP practices are closed. The on-call team can usually access the system and fax the prescriptions to the pharmacy, but the effectiveness of this process varies across the UK.

The US Government programme based upon the Health Information Technology for Economic and Clinical Health (HITECH) Act of 2009 provided financial incentives to physician practices and hospitals to foster digital health implementation and improve the quality of care for patients. These incentives have since led to the widespread adoption as well as the meaningful use of EHR across all levels of healthcare in the US with the resultant digital health transformation and improved clinical outcomes (Adler-Milstein, Everson, & Lee, 2015; Murphy, 2014; Nuckols et al., 2014). UK model of adoption of primary care EHRs may be a better model in terms of a limited number of carefully vetted systems, low costs, and robust interoperability with many hospitals in West Yorkshire (Martin & Saffi, 2020).

6.4.3 Reflections on data entry at Festac PHC

Inconsistencies in EHR data entry during patient encounters (Figures 13-14 in [Section 5.4.5](#)) occur due to several factors, including human, organisational and system. The willingness of clinical staff to use the new system was lacking because of the perception that the system will add to their existing workload, the realities of data entry and the shortage of health workers in LMICs (Wallis, Blessing, Dalwai, & Shin, 2017). Only a few HCPs are keen on using the system. Hence, little or no data entry is done if the active ones are not on shift. Sometimes, the HCPs attend staff verification exercises, leaving the EHR system with casual staff who do not have permission to use the system due to clinical accountability requirements. Lack of leadership motivation or incentive to use the system could prevent HIOs, doctors, nurses and midwives from seeing the need to do data entry. System downtime happens occasionally; when this happens, there is no health IT support technician on the ground to resolve the issue. Hence, the PHC relies on the research team, who, not contractually obliged, may sometimes help out. To resolve system issues, the PHC management could employ an IT support technician on a full-time or part-time basis, but the management should be keen and be ready to include the employment cost in the clinic's budget. The lack of effective human, organisational and system support is responsible for inconsistent data entry to the EHR system, leading to poor clinical benefits and inaccurate reporting.

There is a growing interest in alternative data entry approaches, including the “scribe” model, natural language processing (NLP)-enabled data capture and optical mark recognition (OMR). These alternative approaches could address the issue of clinicians' avoidance of using the EHR system. The “scribe” model introduces a way of working where a human scribe (a volunteer or health professional) manually enters the applicable information such as observations, diagnosis and test results into the EHR during the patient visit, as spoken aloud by the doctor or nurse (Howard et al., 2012). However, this could impact clinical data quality because the scribe might not be a suitably qualified clinician and prone to data entry errors, which, in turn, could affect health outcomes. The NLP data capture application allows HCPs, especially doctors, to

capture structured data with unstructured dictation into the EHR (Kaufman et al., 2016). OMR is a non-dictation but a scanning method of data capture where the OMR software processes paper clinical forms that have been scanned with a modest office scanner or low-cost document camera (Bergeron, 2005). This approach ensures that clinicians who record clinical data on paper do not have to enter the data once or twice in other records. It requires stability of systems, a person to oversee the scanning and data extraction, and user confidence. It might develop as a model to overcome a backlog of data entry in the EHR, increasing the value for clinicians.

6.5 Limitations of the study

The study has several limitations in developing the ToC. Firstly, the author was extensively involved in developing and revising the ToC map, which may have contributed to a social desirability bias. Secondly, the author mainly worked on the analysis of the ToC maps. However, the HCPs and stakeholders would have been engaged in the analysis, but they were not well versed with the technicalities of the ToC approach. Future studies will ensure HCPs are familiarised with the ToC analysis. The relevant stakeholders were fully engaged in the clinical, data collection (interviews and workshop) and managerial aspects of the design.

Chapter 7: Conclusions

7.1 Overview

The practical application of the Theory of Change (ToC) approach provided a better understanding of the successes and failures experienced in this study. Despite the successful EHR implementation study, there are major take-home lessons to spotlight regarding sustainability shortcomings, technical challenges and contextual issues. In fact, these issues are common with EHR implementations in other low- and middle-income countries (Section 6.4.1). The EHR system stopped working four months after the end of the pilot study as there was no counterpart funding from the local authority responsible for the primary health centre. Efforts were made by producing a letter to guarantee the system's sustainability beyond the GCRF funding lifetime; there was a signed agreement by the relevant stakeholders, but it did not go beyond the paper. Although the project was not sustained, benefits were sustained for staff and the clinic 12 months after the pilot study. The sustained improvements included trained healthcare professionals, changed mindsets from using paper systems towards digital health transformation, and using the project's laptops for aggregate data collection for DHIS2-based national health information management system. The scheduling of tasks and time for the technical implementation were underestimated; this led to a slight delay in the system go-live. There was a change in the network design from cloud to wired local area network (LAN) due to poor internet access (4G) on the clinical site and lack of financial commitment from the PHC management to continue the wireless subscription beyond the GCRF funding lifetime. Also, compatibility issues with Java, MySQL, and Apache Tomcat stretched the implementation time. It is worth allowing more time for the readiness assessment to be done entirely on-site so that the implementer/developer can identify the infrastructural issues that may hinder the implementation. Ultimately, the sustainability and technical issues were connected to the enabling environment within Festac PHC. Initially, the management and HCPs were very enthusiastic about the EHR implementation. As the implementation progressed, the clinicians avoided using the system because they claimed that EHR added to their

workload. The clinical heads had to find ways to encourage the use of the systems. Hence, getting more substantial buy-in and influential local champions is paramount to push the system's adoption.

7.2 Impact summary

The findings from this study have the following pathways to impact:

- **Research dissemination**
 - i. Publications: the results from the pilot EHR implementation have been submitted to a journal for publication. The findings from the systematic literature review, qualitative analysis and workshop process will be published.
 - ii. Conferences: The results from the pilot study were presented at the MedInfo 2019 conference.
 - iii. Research workshops and seminars.
- **Benefits realisation through the case study**

This study demonstrated the potential to deliver the following outcomes for healthcare professionals and citizens to solve the sustainability gap.

- i. Clinicians
 1. Efficiencies in their job
 2. Empowerment from training and exposure to digital health
 3. Best practice regarding privacy, security and trust with patient data
- ii. Patients/Citizens
 1. Better clinical outcomes
 2. Privacy and security of their records
 3. Time savings: length of stay is reduced, no need to search for patients' paper folders
 4. Cost savings: they do not have to pay for paper hospital file

5. Long-term implications – healthy lifestyle for patients

Collaboration with the global community such as the International Medical Informatics Association (IMIA) and WHO.

7.3 Original contributions to knowledge

What was previously known:

- Theory of Change (ToC) approach is effective in engaging stakeholders, getting better understanding of and evaluating the complexities of the context where an intervention has been implemented.
- ToC is both a process and a product and articulates the mechanisms of change.
- ToC has little public use in health informatics projects.

What this study adds:

- The ToC approach can be used to formulate the preconditions to achieve the long-term goal to improve the delivery of maternal and healthcare (MCH).
- ToC is a **powerful tool to guide the implementation of health informatics projects**.
- The success criteria proposed by Deriel et al. (2018) and Fritz et al. (2015) were used to supplement ToC, which is a **methodological innovation**. As far as it is known, this is the first study to introduce this innovation.
- The **ToC maps** developed in this study can guide new EHR implementations in LMICs. It can help the stakeholders to clarify the long-term change, wider benefits, measurable effects, outputs, inputs and the underlying assumptions that link the ToC components. The benefits realised so far in Festac primary health centre were:
 - Reduced costs of paper processes.
 - Easier clinical audit.
 - Efficient workflow for healthcare professionals.
 - EHR as a foundation for interoperability.

What this study adds (Continued):

- A detailed explanation of success criteria, lessons learned and implications for EHR implementations in LMICs. The following lessons were learnt EHR implementation experience in Festac PHC.
 - **Ethical:** The concept of ownership of data for patients is not widely appreciated.
 - **Political:** It is vital to build informal relationships and maintain communication with reliable local contacts, particularly the ones that are keen about the digital health transformation agenda. Sometimes, this approach works differently in developing and developed countries.
 - **Organisational:** Although the benefits of EHR were visible, it was hard for the head of units to convince the clinicians to use the EHR.
 - **Financial:** The initial cost of implementation was high, and funds mainly came from the funding partner. Supplementary funding from the local authority directing Festac PHC would have significantly moved the project forward.
 - **Functionality:** JavaScript was used to optimise the e-forms (hide and show content) to encourage efficient data entry for health information officers and to reduce the boredom of scrolling through lengthy webpages each time antenatal care (ANC) and immunisation records are entered.
 - **Technical:** There were compatibility issues with Java Runtime Environment (JRE), MYSQL server and Apache Tomcat. These issues took about 3 days to resolve until the compatible versions were identified. Future implementers need to be aware of potential compatibility issues with software applications before implementation and at the same time, to be tenacious/dedicated because it can be a discouraging experience especially when the expectations are high for a timely implementation delivery.
 - **Training:** The lack of technical support affected the smooth running of the system, and the clinicians were left at the mercy of the busy implementer. Provisions should be made by the PHC management for a periodic staff training and system support to ensure the continuous staff development and effective running of the EHR, post-implementation.
 - **Sustainability:** The funding stopped, but the PHC management did not continue with the financing. Hence, there should be a firm commitment from the local authority to provide supplementary funding for the operation and maintenance of the EHR, especially before the project initiation and after the implementation.

7.4 Conclusion

This research presented ToC as a rewarding approach in framing dialogue with stakeholders. It has functioned as a valuable framework for planning an EHR implementation and the steps needed to define the requirements and the success factors, likelihood of longer-term success and evaluation metrics. For new implementers, knowing how to structure this implementation process could be very useful. Future health IT implementation in primary care can adapt the ToC approach to their contexts with necessary modifications based on inherent characteristics. The pilot EHR implementation served as a small-scale foundation that can support health information exchange and as a digital health exemplar for other PHCs in Lagos State and Nigeria. Other healthcare providers can learn from and build on the implementation to support the delivery of MCH and other health services.

Furthermore, the pilot EHR system represented a digital enabler that provides computable and machine-readable health data, the necessary first step towards more complex aspects such as interoperability, clinical decision support and a learning health system. Further work is needed to extend the scope of the implementation to cover other public PHCs. There is a need to secure more funds for additional infrastructure alongside solid leadership to ensure sustainability and scalability. Also, it will be helpful to explore the interoperability of health data across public PHCs by designing a national health data model for maternal health services data set. The model should be based on established data standards and examining the preconditions and drivers for implementing such a model.

7.5 Further work

A consolidated realist synthesis can be conducted following the Theory of Change that was developed in this study. This kind of synthesis helps the reviewers and policymakers to know ‘what works’ before commencing any digital health implementation using a realist approach – Context-Mechanism-Outcome configuration (Pawson, 2002).

This study highlights the need for further work in these areas:

- More evidence-based digital health implementation studies should be conducted and published focusing on maternal and child healthcare in Nigeria/LMICs.
- From the outset, all relevant stakeholders in LMICs must make arrangements for the sustainability of any digital health implementation and ensure accountable measures are put in place to implement the arrangements.
- Implementers of digital health should ensure that they conduct a readiness assessment for the health facility before commencing implementation.
- The management and the staff must be involved in the digital health implementation from start to finish. Meaningful engagement of the relevant stakeholders is a precursor to the implementation success.
- The implementation of standardised data models for maternal and child health records must be considered (given more thought) by local, regional, national and international stakeholders.

References

- Adamu, J., Hamzah, R., & Rosli, M. M. (2020). Security issues and framework of electronic medical record: A review. *Bulletin of Electrical Engineering and Informatics*, 9(2), 565–572. <https://doi.org/10.11591/eei.v9i2.2064>
- Adeniran, I., Otokiti, K., Otokiti, K. V., & Durojaye, P. (2020). Climate Change Impacts in a Rapidly Growing Urban Region-A Case Study of Ikeja, Lagos, Nigeria. *International Journal of Environmental Planning and Management*, 6(1), 13–23. Retrieved from <http://www.aiscience.org/journal/ijepm><http://creativecommons.org/licenses/by/4.0/>
- Adler-Milstein, J., Everson, J., & Lee, S. Y. D. (2015). EHR Adoption and Hospital Performance: Time-Related Effects. *Health Services Research*, 50(6). <https://doi.org/10.1111/1475-6773.12406>
- Amoroso, C. L., Akimana, B., Wise, B., & Fraser, H. S. F. (2010). Using electronic medical records for HIV care in rural Rwanda. *Studies in Health Technology and Informatics*, 160(PART 1). <https://doi.org/10.3233/978-1-60750-588-4-337>
- Amutah-Onukagha, N., Rodriguez, M., Opara, I., Gardner, M., Assan, M., Hammond, R., ... Farag, E. (2017). Progresses and Challenges of Utilizing Traditional Birth Attendants in Maternal and Child Health in Nigeria. *International Journal of MCH and AIDS (IJMA)*, 6(2), 130–138. <https://doi.org/10.21106/ijma.216>
- ATLAS.ti. (2020). What is ATLAS.ti 9. Retrieved October 26, 2020, from <https://atlasti.com/>
- Attah, A. O. (2017). *Implementing the Electronic Health Record in a Nigerian Secondary Healthcare Facility: Prospects and Challenges*. UiT-The Arctic University of Norway.
- Baxter, S. K., Blank, L., Woods, H. B., Payne, N., Rimmer, M., & Goyder, E. (2014). Using logic model methods in systematic review synthesis: Describing complex pathways in referral management interventions. *BMC Medical Research Methodology*, 14(1), 1–9. <https://doi.org/10.1186/1471-2288-14-62>
- Begum, R., Smith Ryan, M., Winther, C. H., Wang, J. J., Bardach, N. S., Parsons, A. H., ... Dudley, R. A. (2013). Small practices' experience with EHR, quality measurement, and incentives. *American Journal of Managed Care*, 19(10 Spec No), eSP12-8.
- Benson, T. (2002). Why general practitioners use computers and hospital doctors do not—Part 1: Incentives. *Bmj*, 325(7372), 1086–1089. <https://doi.org/10.1136/bmj.325.7372.1086>

- Bergeron, B. (2005). Clinical Data Capture: OMR and OCR and Your Flatbed Scanner. Retrieved August 19, 2020, from https://www.medscape.com/viewarticle/497865_2
- Bowen, G. A. (2009). Document analysis as a qualitative research method. *Qualitative Research Journal*, 9(2), 27–40. <https://doi.org/10.3316/QRJ0902027>
- Braithwaite, J., Glasziou, P., & Westbrook, J. (2020). The three numbers you need to know about healthcare: The 60-30-10 Challenge. *BMC Medicine*, 18(1), 1–8. <https://doi.org/10.1186/s12916-020-01563-4>
- Breuer, E., Lee, L., De Silva, M., & Lund, C. (2016). Using theory of change to design and evaluate public health interventions: A systematic review. *Implementation Science*, 11(1). <https://doi.org/10.1186/s13012-016-0422-6>
- Brown, O. (2018). *Fixing Healthcare in NIGERIA*. Retrieved from <http://www.drolaorekunrinbrown.com/wp-content/uploads/2019/03/Fixing-Nigeria-2.pdf>
- Chen, H.-T., & Rossi, P. H. (1983). Evaluating with sense: The theory-driven approach. *Evaluation Review*, 7(3), 283–302. <https://doi.org/10.1177/0193841X8300700301>
- Chibanda, D., Verhey, R., Munetsi, E., Cowan, F. M., & Lund, C. (2016). Using a theory driven approach to develop and evaluate a complex mental health intervention: The friendship bench project in Zimbabwe. *International Journal of Mental Health Systems*, 10(1), 1–9. <https://doi.org/10.1186/s13033-016-0050-1>
- Clinical Data Interchange Standards Consortium. (2020). Clear Data. Clear Impact. Retrieved March 23, 2021, from <https://www.cdisc.org/>
- Connell, J. P., & Kubisch, A. C. (1998). Applying a Theory of Change Approach to the Evaluation of Comprehensive Community Initiatives: Progress, Prospects, and Problems. *Theory Measurement and Analysis*. [https://doi.org/ISBN 0-89843-349-9](https://doi.org/ISBN%200-89843-349-9)
- Cordeiro, L., & Soares, C. B. (2018). Action research in the healthcare field: a scoping review. In *JBIR Database of Systematic Reviews and Implementation Reports* (Vol. 16). <https://doi.org/10.1124/JBISRIR-2016-003200>
- Craig, P., Dieppe, P., Macintyre, S., Michie, S., Nazareth, I., & Petticrew, M. (2013). Developing and evaluating complex interventions: The new Medical Research Council guidance. *International Journal of Nursing Studies*, 50(5), 587–592. <https://doi.org/10.1016/j.ijnurstu.2012.09.010>
- De Silva, M. J., Breuer, E., Lee, L., Asher, L., Chowdhary, N., Lund, C., & Patel, V. (2014). Theory of Change: a theory-driven approach to enhance the Medical Research Council's framework for complex interventions. *Trials*, 15(1), 267. <https://doi.org/10.1186/1745-6215-15-267>

- DeLone, W. H., & McLean, E. R. (2003). The DeLone and McLean model of information systems success: A ten-year update. *Journal of Management Information Systems*, 19(4), 9–30. <https://doi.org/10.1080/07421222.2003.11045748>
- Deriel, E., Puttkammer, N., Hyppolite, N., Diallo, J., Wagner, S., Honoré, J. G., ... Barnhart, S. (2018). Success factors for implementing and sustaining a mature electronic medical record in a low-resource setting: A case study of iSanté in Haiti. *Health Policy and Planning*, 33(2), 237–246. <https://doi.org/10.1093/heapol/czx171>
- Dobrow, M. J., Bytautas, J. P., Tharmalingam, S., & Hagens, S. (2019). Interoperable electronic health records and health information exchanges: Systematic review. *Journal of Medical Internet Research*, Vol. 21. *Journal of Medical Internet Research*. <https://doi.org/10.2196/12607>
- Douglas, G. P., Gadabu, O. J., Joukes, S., Mumba, S., McKay, M. V., Ben-Smith, A., ... Chimbwandira, F. (2010). Using Touchscreen electronic medical record systems to support and monitor national scale-up of antiretroviral therapy in Malawi. *PLoS Medicine*. <https://doi.org/10.1371/journal.pmed.1000319>
- Dye, C., Boerma, T., Evans, D., Harries, A., Lienhardt, C., McManus, J., ... Zachariah, R. (2013). *Research for universal health coverage*. (Vol. 5). Geneva. <https://doi.org/10.1126/scitranslmed.3006971>
- Ebenso, B., Allsop, M. J., Okusanya, B., Akaba, G., Tukur, J., Okunade, K., ... Newell, J. N. (2018). Impact of using eHealth tools to extend health services to rural areas of Nigeria: Protocol for a mixed-method, non-randomised cluster trial. *BMJ Open*, 8(10), 1–8. <https://doi.org/10.1136/bmjopen-2018-022174>
- Emmanuel, A. N. (2014). Challenges of implementing sustainable health care delivery in Nigeria under environmental uncertainty. *Journal of Hospital Administration*, 3(6), p113. <https://doi.org/10.5430/jha.v3n6p113>
- Evans, R. S. (2016). Electronic Health Records: Then, Now, and in the Future. *Yearbook of Medical Informatics*, S48–S61. <https://doi.org/10.15265/IYS-2016-s006>
- Eze, E., Gleasure, R., & Heavin, C. (2016). Reviewing mHealth in Developing Countries: A Stakeholder Perspective. *Procedia Computer Science*, 100, 1024–1032. <https://doi.org/10.1016/j.procs.2016.09.276>
- Federal Government of Nigeria. (2018). *National Strategic Health Development Plan II (2018 - 2022)*. Retrieved from <http://health.gov.ng/doc/NSHDP II Final.pdf>
- Federal Ministry of Health. (2016). *National Health ICT Strategic Framework 2015 - 2020*.
- Federal Ministry of Health. (2019). Nigeria Health Facility Registry. Retrieved June 21, 2021, from <https://hfr.health.gov.ng/facilities/hospitals-list>

- Federal Republic of Nigeria. (2014). National Health Act, 2014. *Official Gazette*, Vol. 101, pp. A139-172. Retrieved from https://nigeriahealthwatch.com/wp-content/uploads/bsk-pdf-manager/2018/07/01_-Official-Gazette-of-the-National-Health-Act-FGN.pdf
- Fraser, H. S. F., Habib, A., Goodrich, M., Thomas, D., Blaya, J. A., Fils-Aime, J. R., ... Becerra, M. C. (2013). E-Health systems for management of MDR-TB in resource-poor environments: A decade of experience and recommendations for future work. In *Studies in Health Technology and Informatics* (Vol. 192). <https://doi.org/10.3233/978-1-61499-289-9-627>
- Fritz, F., Tilahun, B., & Dugas, M. (2015). Success criteria for electronic medical record implementations in low-resource settings: a systematic review. *Journal of the American Medical Informatics Association*, 22(2), 479-488. <https://doi.org/10.1093/jamia/ocu038>
- Gale, N. K., Heath, G., Cameron, E., Rashid, S., & Redwood, S. (2013). Using the framework method for the analysis of qualitative data in multi-disciplinary health research. *BMC Medical Research Methodology*, 13(1), 117. <https://doi.org/10.1186/1471-2288-13-117>
- Goeschel, C. A., Weiss, W. M., & Pronovost, P. J. (2012). Using a logic model to design and evaluate quality and patient safety improvement programs. *International Journal for Quality in Health Care*, 24(4), 330-337. <https://doi.org/10.1093/intqhc/mzso29>
- HIMSS. (2021). What is Interoperability? Retrieved September 24, 2019, from <https://www.himss.org/resources/interoperability-healthcare#Part1>
- HL7. (2020). Welcome to FHIR®. Retrieved October 9, 2020, from <https://www.hl7.org/fhir/>
- HL7. (2021). About HL7. Retrieved March 23, 2021, from <https://www.hl7.org/about/index.cfm?ref=footer>
- Howard, K. A., Helé, K., Salibi, N., Wilcox, S., & Cohen, M. (2012). *Adapting the EHR Scribe Model to Community Health Centers: The Experience of Shasta Community Health Center's Pilot*. Berkeley. Retrieved from <https://informingchange.com/>
- Hughes, J. A., & Sharrock, W. W. (2016). *The philosophy of social research*. Routledge.
- Idowu, P., Cornford, D., & Bastin, L. (2008). Health informatics deployment in Nigeria. *Journal of Health Informatics in Developing Countries*, 2(1), 16-23.
- Jenkins, C. S. (2010). What Is Ontological Realism? *Philosophy Compass*, 5(10), 880-890. <https://doi.org/10.1111/j.1747-9991.2010.00332.x>

- Johnson, K. E., Kamineni, A., Fuller, S., Olmstead, D., & Wernli, K. J. (2014). How the Provenance of Electronic Health Record Data Matters for Research: A Case Example Using System Mapping. *EGEMs (Generating Evidence & Methods to Improve Patient Outcomes)*, 2(1), 4. <https://doi.org/10.13063/2327-9214.1058>
- Kahn, M. G., Batson, D., & Schilling, L. M. (2012). Data model considerations for clinical effectiveness researchers. *Medical Care*, 50(SUPPL. 1), 60–67. <https://doi.org/10.1097/MLR.0b013e318259bff4>
- Karara, G., Verbeke, F., & Nyssen, M. (2015). The Role of Hospital Information Systems in Universal Health Coverage Monitoring in Rwanda. *Studies in Health Technology and Informatics*, 216, 193–197. <https://doi.org/10.3233/978-1-61499-564-7-193>
- Kaufman, D. R., Sheehan, B., Stetson, P., Bhatt, A. R., Field, A. I., Patel, C., & Maisel, J. M. (2016). Natural Language Processing–Enabled and Conventional Data Capture Methods for Input to Electronic Health Records: A Comparative Usability Study. *JMIR Medical Informatics*, 4(4), e35. <https://doi.org/10.2196/medinform.5544>
- Kayode, I., Taiwo, E., Adetoro, O., & Sam, T. (2020). Susceptibility status of mosquitoes (Diptera:Culicidae) to malathion in Lagos, Nigeria. *Animal Research International*, 17(1), 3541–3549.
- King, A., & Crewe, I. (2013). *The blunders of our governments*. London: Oneworld Publications.
- Klein, H. K., & Myers, M. D. (1999). A set of principles for conducting and evaluating interpretive field studies in information systems. *MIS Quarterly: Management Information Systems*, 23(1), 67–94. <https://doi.org/10.2307/249410>
- Lagos State Ministry of Health. (2017). Lagos State Maternal and Child Mortality Reduction (MCMR) Program: Good Practices Memo. Retrieved June 23, 2021, from <https://health.lagosstate.gov.ng/lagos-state-maternal-and-child-mortality-reduction-mcmr-program/>
- Lawal, U., Abdul-Lateef, D., Ismaila, B., Yusuf, R. A., & Aina, A. (2020). Transformative urban governance: confronting urbanization challenges with geospatial technologies in Lagos, Nigeria. *GeoJournal*, 85(4), 1039–1056. <https://doi.org/10.1007/s10708-019-10009-1>
- Lee, A. S. (2004). Thinking about social theory and philosophy for information systems. In J. Mingers & L. Willcocks (Eds.), *Social theory and philosophy for Information Systems*. Chichester: Wiley.
- Lee, S. H., Nurmatov, U. B., Nwaru, B. I., Mukherjee, M., Grant, L., & Pagliari, C. (2016). Effectiveness of mHealth interventions for maternal, newborn and child health in low- and middle-income countries: Systematic review and meta-analysis. *Journal*

- of *Global Health*, 6(1). <https://doi.org/10.7189/jogh.06.010401>
- Levers, M.-J. D. (2013). Philosophical paradigms, grounded theory, and perspectives on emergence. *SAGE Open*, 3(4). <https://doi.org/10.1177/2158244013517243>
- Likert, R. (1932). A technique for the measurement of attitudes. *Archives of Psychology*, 22 140, 55. <https://doi.org/2731047>
- Luna, D., Almerares, A., Mayan, J. C., González Bernaldo de Quirós, F., & Otero, C. (2014). Health Informatics in Developing Countries: Going beyond Pilot Practices to Sustainable Implementations: A Review of the Current Challenges. *Healthcare Informatics Research*, 20(1), 3. <https://doi.org/10.4258/hir.2014.20.1.3>
- Mackey, T. K., Vian, T., & Kohler, J. (2018). The sustainable development goals as a framework to combat health-sector corruption. *Bulletin of the World Health Organization*, 96(9), 634–643. <https://doi.org/10.2471/BLT.18.209502>
- Maden, M., Cunliffe, A., McMahon, N., Booth, A., Carey, G. M., Paisley, S., ... Gabbay, M. (2017). Use of programme theory to understand the differential effects of interventions across socio-economic groups in systematic reviews—a systematic methodology review. *Systematic Reviews*, 6(1), 1–23. <https://doi.org/10.1186/s13643-017-0638-9>
- Makinde, O. A., Sule, A., Ayankogbe, O., & Boone, D. (2018). Distribution of health facilities in Nigeria: Implications and options for Universal Health Coverage. *International Journal of Health Planning and Management*, 33(4), e1179–e1192. <https://doi.org/10.1002/hpm.2603>
- Martin, P. M., & Saffi, L. (2020). Electronic Health Record and Problem Lists in Leeds, United Kingdom: Variability of general practitioners' views. *Health Informatics Journal*, 26(3), 1898–1911. <https://doi.org/10.1177/1460458219895184>
- Mcnabb, M., Chukwu, E., Ojo, O., & Shekhar, N. (2015). Assessment of the Quality of Antenatal Care Services Provided by Health Workers Using a Mobile Phone Decision Support Application in Northern Nigeria : A Pre / Post-Intervention Study. *PloS ONE*, 10(5), 1–11. <https://doi.org/10.1371/journal.pone.0123940>
- Meskó, B., Drobni, Z., Bényei, É., Gergely, B., & Györffy, Z. (2017). Digital health is a cultural transformation of traditional healthcare. *MHealth*, 1–8. <https://doi.org/10.21037/mhealth.2017.08.07>
- Meyers, D. J., Forsyth, T. M., & Velasquez, A. (2017). 4 Culture of Quality and Safety: A Prerequisite for Any Informatics Intervention. In L. A. Celi, H. Fraser, V. Nikore, J. S. Osorio, & K. E. Paik (Eds.), *Global Health Informatics: Principles of EHealth and MHealth to Improve Quality of Care* (p. 49). MIT Press.

- Mirzoev, T., Etiaba, E., Ebenso, B., Uzochukwu, B., Manzano, A., Onwujekwe, O., ... Ensor, T. (2016). Study protocol: Realist evaluation of effectiveness and sustainability of a community health workers programme in improving maternal and child health in Nigeria. *Implementation Science*, 11(1), 1–11. <https://doi.org/10.1186/S13012-016-0443-1>
- Moher, D., Larissa, S., Clarke, M., Gherzi, D., Liberati, A., Petticrew, M., ... Stewart, L. A. (2015). Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. *Syst Rev.*, 4(1), 1–19. <https://doi.org/10.1186/2046-4053-4-1>
- Muinga, N., Magare, S., Monda, J., Kamau, O., Houston, S., Fraser, H., ... Paton, C. (2018). Implementing an open source electronic health record system in kenyan health care facilities: Case study. *Journal of Medical Internet Research*, 20(4), 1–13. <https://doi.org/10.2196/medinform.8403>
- Murphy, E. V. (2014). Clinical decision support: Effectiveness in improving quality processes and clinical outcomes and factors that may influence success. *Yale Journal of Biology and Medicine*, 87(2), 187–197.
- National Institutes of Health. (2006). Electronic Health Records Overview. In *Center for Enterprise Modernization McLean, Virginia*. Retrieved from <https://www.himss.org/electronic-health-records-overview-nih-national-center-research-resources>
- National Population Commission (NPC) [Nigeria], & ICF. (2019). *Nigeria Demographic and Health Survey 2018*. Abuja and Rockville: NPC and ICF.
- Nguyen, L., Bellucci, E., & Nguyen, L. T. (2014). Electronic health records implementation: An evaluation of information system impact and contingency factors. *International Journal of Medical Informatics*, 83(11), 779–796. <https://doi.org/10.1016/j.ijmedinf.2014.06.011>
- Nkwake, A. M. (2020). *Working with Assumptions in International Development Program Evaluation* (Second). Springer Nature.
- Nta, I. E., Sani, N., Gomez, G., Aghatise, J., Chiazor, E., Okere, N., & Onah, A. (2017). Status of Primary Health Workforce in a Nigerian State: Findings from Enrollment into a Digital Health Workforce Registry. *Annals of Global Health*, 83(1).
- Nuckols, T. K., Smith-Spangler, C., Morton, S. C., Asch, S. M., Patel, V. M., Anderson, L. J., ... Shekelle, P. G. (2014). The effectiveness of computerized order entry at reducing preventable adverse drug events and medication errors in hospital settings: a systematic review and meta-analysis. *Systematic Reviews*, 3. <https://doi.org/10.1186/2046-4053-3-56>

- Oates, B. J. (2006). *Researching Information Systems and Computing*. London: SAGE.
- Obasola, O I, & Mabawonku, I. M. (2018). Mothers' perception of maternal and child health information disseminated via different modes of ICT in Nigeria. *Health Information and Libraries Journal*, 35(4), 309–318. <https://doi.org/10.1111/hir.12235>
- Obasola, Oluwaseun Ireti, Mabawonku, I., & Lagunju, I. (2015). A Review of e-Health Interventions for Maternal and Child Health in Sub-Sahara Africa. *Maternal and Child Health Journal*, 19(8), 1813–1824. <https://doi.org/10.1007/s10995-015-1695-0>
- Odekunle, F. F., Odekunle, R. O., & Shankar, S. (2017). Why sub-Saharan Africa lags in electronic health record adoption and possible strategies to increase its adoption in this region. *International Journal of Health Sciences*, 11(4), 59–64. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/29085270> <http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=PMC5654179>
- Odetola, T. D., & Okanlawon, F. (2014). Assessment of Mobile Health Nursing Intervention Knowledge among Community Health Nurses in Oyo State, Nigeria. *Afr J Med Med Sci*, 43(Suppl 1), 147–155. <https://doi.org/10.1007/s12671-013-0269-8.Moving>
- OECD. (2015). *Health at a Glance 2015: OECD Indicators*. Paris: OECD Publishing. https://doi.org/10.1787/health_glance-2015-en
- Ojo, A. I. (2017). Validation of the delone and mclean information systems success model. *Healthcare Informatics Research*, 23(1), 60–66. <https://doi.org/10.4258/hir.2017.23.1.60>
- Olaronke, I., Ishaya, G., Rhoda, I., & Janet, O. (2013). Interoperability in Nigeria Healthcare System: The Ways Forward. *International Journal of Information Engineering and Electronic Business*, 4(4), 16–23. <https://doi.org/10.5815/>
- Oluoch, T., & de Keizer, N. F. (2016). Evaluation of Health IT in Low-Income Countries. *Studies in Health Technology & Informatics*, 222, 324–335. <https://doi.org/10.3233/978-1-61499-635-4-324>
- Oluoch, T., Katana, A., Kwaro, D., Santas, X., Langat, P., Muthusi, K., ... De Keizer, N. (2016). Effect of a clinical decision support system on early action on immunological treatment failure in patients with HIV in Kenya: a cluster randomised controlled trial. *Lancet HIV*, 3(2), e76–e84. [https://doi.org/10.1016/S2352-3018\(15\)00242-8](https://doi.org/10.1016/S2352-3018(15)00242-8).
- Omotayo, O., & Udosen, A. (2020). How Lagos State is tackling the challenge of alternative birth methods. Retrieved July 21, 2021, from <https://nigeriahealthwatch.medium.com/how-lagos-state-is-tackling-the-challenge-of-alternative-birth-methods-d003f256ae3d>

- OpenEHR. (2020). What is openEHR? Retrieved October 9, 2020, from https://www.openehr.org/about/what_is_openehr
- OpenMRS. (2016). OpenMRS. Retrieved March 9, 2020, from <https://openmrs.org/>
- Orlikowski, W. J., & Baroudi, J. J. (1991). Studying Information Technology in Organizations: Research Approaches and Assumptions. *Information Systems Research*, 2(1), 1–28.
- Oza, S., Jazayeri, D., Teich, J. M., Ball, E., Nankubuge, P. A., Rwebembera, J., ... Fraser, H. S. (2017). Development and deployment of the OpenMRS-Ebola electronic health record system for an Ebola treatment center in Sierra Leone. *Journal of Medical Internet Research*, 19(8). <https://doi.org/10.2196/jmir.7881>
- Pawson, R. (2002). Evidence-based Policy: The Promise of 'Realist Synthesis'. *Evaluation*, 8(3), 340–358. <https://doi.org/10.1177/135638902401462448>
- Persse, J. (2016). *The ITIL Process Manual*. Van Haren.
- Piette, J. D., Lun, K. C., Moura, L. a, Fraser, H. S. F., Mechael, P. N., Powell, J., & Khoja, S. R. (2012). Impacts of e-health on the outcomes of care in low- and middle-income countries: where do we go from here? *Bulletin of the World Health Organization*, 90(5), 365–372. <https://doi.org/10.2471/BLT.11.099069>
- Popay, J., Roberts, H., Sowden, A., Petticrew, M., Arai, L., Rodgers, M., & Britten, N. (2006). Narrative Synthesis in Systematic Reviews: A Product from the ESRC Methods Programme. *ESRC Methods Programme*, (2006), 93. <https://doi.org/10.13140/2.1.1018.4643>
- Professional Record Standards Board. (2019). Maternity record standard. Retrieved October 31, 2019, from <https://theprsb.org/standards/maternityrecord/>
- Purkayastha, S., Allam, R., Maity, P., & Gichoya, J. W. (2019). Comparison of Open-Source Electronic Health Record Systems Based on Functional and User Performance Criteria. *Healthcare Informatics Research*, 25(2), 89. <https://doi.org/10.4258/hir.2019.25.2.89>
- Reis, Z. S. N., Maia, T. A., Marcolino, M. S., Becerra-Posada, F., Novillo-Ortiz, D., & Ribeiro, A. L. P. (2017). Is There Evidence of Cost Benefits of Electronic Medical Records, Standards, or Interoperability in Hospital Information Systems? Overview of Systematic Reviews. *JMIR Medical Informatics*. <https://doi.org/10.2196/medinform.7400>
- Results for Development Institute. (2014). *Spending to Save: Challenges and Opportunities for Financing Nigeria's Saving One Million Lives Initiative*. Retrieved from <https://r4d.org/projects/saving-one-million-lives-nigeria/>

- Rigby, M., Ammenwerth, E., Beuscart-Zephir, M.-C., Brender, J., Hypponen, H., Melia, S., ... de Keizer, N. (2013). Evidence Based Health Informatics: 10 Years of Efforts to Promote the Principle. Joint Contribution of IMIA WG EVAL and EFMI WG EVAL. *Yearbook of Medical Informatics*, 8, 34–46. <https://doi.org/me13010034> [pii]
- Rogers, P. J. (2008). Using programme theory to evaluate complicated and complex aspects of interventions. *Evaluation*, 14(1), 29–48. <https://doi.org/10.1177/1356389007084674>
- Rumball-Smith, J., Ross, K., & Bates, D. W. (2019). Late adopters of the electronic health record should move now. *BMJ Quality and Safety*, 1–3. <https://doi.org/10.1136/bmjqs-2019-010002>
- Sansone, S., & Rocca-Serra, P. (2016). *Interoperability Standards - Digital Objects in Their Own Right*. Wellcome Trust. <https://doi.org/10.6084/M9.FIGSHARE.4055496.V1>
- Schade, C. P., Sullivan, F. M., de Lusignan, S., & Madeley, J. (2006). e-Prescribing, Efficiency, Quality: Lessons from the Computerization of UK Family Practice. *Journal of the American Medical Informatics Association*, 13(5), 470–475. <https://doi.org/10.1197/jamia.M2041>
- Scott, P. J. (2016). Mixed methods: A paradigm for holistic evaluation of health IT. *Evidence-Based Health Informatics: Promoting Safety and Efficiency through Scientific Methods and Ethical Policy*, 222, 102–113. <https://doi.org/10.3233/978-1-61499-635-4-102>
- Scott, P. J., & Briggs, J. S. (2010). STAT-HI: A Socio-Technical Assessment Tool for Health Informatics Implementations. *The Open Medical Informatics Journal*, 4, 214–220. <https://doi.org/10.2174/1874431101004010214>
- Scott, P. J., Curley, P. J., Williams, P. B., Linehan, I. P., & Shaha, S. H. (2016). Measuring the operational impact of digitized hospital records: a mixed methods study. *BMC Medical Informatics and Decision Making*, 16(1), 1–13. <https://doi.org/10.1186/s12911-016-0380-6>
- Scott, P. J., & Heitmann, K. U. (2018). Team Competencies and Educational Threshold Concepts for Clinical Information Modelling. *Studies in Health Technology and Informatics*, 255, 252–256. <https://doi.org/10.3233/978-1-61499-921-8-252>
- Smith, S. W., & Koppel, R. (2014). Healthcare information technology's relativity problems: A typology of how patients' physical reality, clinicians' mental models, and healthcare information technology differ. *Journal of the American Medical Informatics Association*, 21(1), 117–131. <https://doi.org/10.1136/amiajnl-2012-001419>
- SNOMED International. (2021). SNOMED. Retrieved March 23, 2021, from <https://www.snomed.org/>

- Taplin, D. H., Clark, H., Collins, E., & Colby, D. C. (2013). *Theory of Change Technical Papers: A series of papers to support development of theories of change based on practice in the field*. New York: ActKnowledge. Retrieved from http://www.theoryofchange.org/wp-content/uploads/toco_library/pdf/ToC-Tech-Papers.pdf
- The World Bank. (2021). Population, total - Nigeria. Retrieved June 30, 2021, from <https://data.worldbank.org/indicator/SP.POP.TOTL?locations=NG>
- Thobias, J., & Kiwanuka, A. (2018). Design and implementation of an m-health data model for improving health information access for reproductive and child health services in low resource settings using a participatory action research approach. *BMC Medical Informatics and Decision Making*, 1–10. <https://doi.org/10.1186/s12911-018-0622-x>
- Thoma, A., & Eaves, F. F. (2015). A brief history of evidence-based medicine (EBM) and the contributions of Dr David Sackett. *Aesthetic Surgery Journal*, 35(8), NP261–NP263. <https://doi.org/10.1093/asj/sjv130>
- Tsokota, T., Chipfumbu, C. T., Mativenga, M., & Mawango, T. I. (2013). ICT4D And The Challenge Of Vandalism In Zimbabwe. *International Journal of Scientific & Technology Research*, 2(8), 21–25.
- UK Research and Innovation. (2021). Global Challenges Research Fund. Retrieved March 22, 2021, from <https://www.ukri.org/our-work/collaborating-internationally/global-challenges-research-fund/>
- UNFPA. (2020). World Population Dashboard - Nigeria. Retrieved January 19, 2021, from <https://www.unfpa.org/data/world-population/NG>
- UNICEF. (2020). Cross-sector indicators. Retrieved January 21, 2021, from UNICEF Data Warehouse website: https://data.unicef.org/resources/data_explorer/unicef_f/?ag=UNICEF&df=GLOBAL_DATAFLOW&ver=1.0&dq=NGA.CME_MRYoT4.&startPeriod=1970&endPeriod=2021&mc_cid=fed5693183&mc_eid=6264edf1d
- United Nations Children’s Fund. (2018). *Levels & trends in child mortality report 2018*. Retrieved from <https://data.unicef.org/wp-content/uploads/2018/10/Child-Mortality-Report-2018.pdf>
- United Nations Foundation. (2014). *Assessing the enabling environment for ICTs for health in Nigeria: a landscape and inventory*. Retrieved from <https://ehealth4everyone.com/wp-content/uploads/2016/01/nigeria-policy-report.pdf>
- Uvhagen, H., Hasson, H., Hansson, J., & Von Knorring, M. (2019). What happened and

- why? A programme theory-based qualitative evaluation of a healthcare-academia partnership reform in primary care. *BMC Health Services Research*, 19(1), 1–12. <https://doi.org/10.1186/s12913-019-4665-1>
- Uzochukwu, B., Onwujekwe, O., & Mbachu C. (2015). Implementing the Basic Health Care Provision Fund in Nigeria: A framework for accountability and good governance. In *Resilient and Responsive Health Systems (RESYS)*. Retrieved from <http://resyst.lshtm.ac.uk/sites/resyst.lshtm.ac.uk/files/docs/reseources/Nigeria-brief.pdf>
- Varrella, S. (2021). GDP of African countries 2020, by country. Retrieved March 29, 2021, from <https://www.statista.com/statistics/1120999/gdp-of-african-countries-by-country/>
- Virtual Doctors. (2020). Technology Medicine. Retrieved March 7, 2020, from <https://www.virtualdoctors.org/>
- Vogel, I. (2012). *Review of the use of 'Theory of Change' in international development*. London: GOV.UK. Retrieved from GOV.UK website: <https://www.gov.uk/government/news/dfid-research-review-of-the-use-of-theory-of-change-in-international-development>
- Wallis, L., Blessing, P., Dalwai, M., & Shin, S. Do. (2017). Integrating mHealth at point of care in low- and middle-income settings: The system perspective. *Global Health Action*, 10(00). <https://doi.org/10.1080/16549716.2017.1327686>
- Waterson, P. (2014). Health information technology and sociotechnical systems: a progress report on recent developments within the UK National Health Service (NHS). *Applied Ergonomics*, 45(2), 150–161. <https://doi.org/10.1016/j.apergo.2013.07.004>
- Weaver, K. (2018). Pragmatic Paradigm. In B. B. Frey (Ed.), *The SAGE Encyclopedia of Educational Research, Measurement, and Evaluation* (pp. 1287–1288). Thousand Oaks: SAGE Publications, Inc. <https://doi.org/https://dx.doi.org/10.4135/9781506326139>
- Weiss, C. H. (1995). Nothing as Practical as Good Theory: Exploring Theory-Based Evaluation for Comprehensive Community Initiatives for Children and Families. *New Approaches to Evaluating Community Initiatives: Concepts, Methods, and Contexts*. <https://doi.org/10.1177/1356389003094007>
- Weiss, C. H. (1997). How can theory-based evaluation make greater headway? *Evaluation Review*, 21(4). <https://doi.org/10.1177/0193841X9702100405>
- Were, M. C., Nyandiko, W. M., Huang, K. T. L., Slaven, J. E., Shen, C., Tierney, W. M., & Vreeman, R. C. (2013). Computer-generated reminders and quality of pediatric HIV

care in a resource-limited setting. *Pediatrics*. <https://doi.org/10.1542/peds.2012-2072>

WHO. (2018). *Global Health Observatory (GHO) data*. World Health Organization. Retrieved from World Health Organization website: http://www.who.int/gho/mortality_burden_disease/en/

WHO Africa. (2019). WHO collaborates with Nigerian Government to update the country health workforce profile. Retrieved June 25, 2021, from <https://www.afro.who.int/news/who-collaborates-nigerian-government-update-country-health-workforce-profile>

World Health Organization. (2016). *Monitoring and evaluating digital health interventions: a practical guide to conducting research and assessment*. Geneva: World Health Organisation. Retrieved from <https://www.who.int/reproductivehealth/publications/mhealth/digital-health-interventions/en/>

World Health Organization. (2017). *Primary health care systems (PRIMASYS): case study from Nigeria*.

World Health Organization. (2019). *WHO guideline: recommendations on digital interventions for health system strengthening: web supplement 2: summary of findings and GRADE tables*.

World Health Organization. (2020a). Global Health Observatory country views. Retrieved January 19, 2021, from WHO website: <http://apps.who.int/gho/data/node.country.country-NGA>

World Health Organization. (2020b). WHO Timeline - COVID-19. Retrieved May 23, 2020, from <https://www.who.int/news-room/detail/27-04-2020-who-timeline---covid-19>

Appendices

Appendix 1 – Abbreviations

ANC	Antenatal care
AOLG	Amuwo Odofin Local Government
CHEW	Community Health Extension Worker
CHO	Community Health Officer
eHealth	Electronic Health
EHR	Electronic Health Record
EMR	Electronic Medical Record
FHIR	Fast Healthcare Interoperability Resource
GCRF	Global Challenges Research Fund
GDPR	General Data Protection Regulation
GP	General Practitioner
HCP	Healthcare Professional
HIC	High-Income Country
HIO	Health Information Officer
HITECH	Health Information Technology for Economic and Clinical Health
ICT	Information and Communication Technology
IS	Information Systems
IT	Information Technology
JRE	Java Runtime Environment
LAN	Local Area Network
LMIC	Low- and Middle-Income Country
M & E	Monitoring and Evaluation
MCH	Maternal and Child Healthcare
mHealth	Mobile Health
MOH	Medical Officer of Health
NDHS	Nigeria Demographic and Health Survey
NDPR	Nigerian Data Protection Regulation
NLP	Natural Language Processing
OMR	Optical Mark Recognition
OpenMRS	Open Medical Records System
PHC	Primary Health Centre
PICOS	Population Intervention Comparator Outcome Study design
PRISMA-P	Preferred Reporting Items for Systematic Reviews and Meta-Analyses Protocol
QDA	Qualitative Data Analysis
RQ	Research Question
TBE	Theory-Based Evaluation
ToC	Theory of Change
UoP	University of Portsmouth
WAR	Web Application Resource
WHO	World Health Organisation

Appendix 2 – Search results

Database	Search strategy	Hits
Web of Science	RQ1: How can EMR implementation effectively benefit maternal and child health in Nigeria?	
Variable 1	TOPIC/ABSTRACT:(electronic medical records OR electronic health records OR digital health OR health information systems OR health information technology OR e health OR ehealth OR e-health)	200,424
Variable 2	TOPIC/ABSTRACT: (effect OR effects OR effectiveness OR efficiency OR efficacy OR efficient OR benefit OR benefits)	8,206,532
Variable 3	TOPIC/ABSTRACT:(maternal health OR child health OR maternity OR infant OR mother)	493,474
Variable 4	TOPIC/ABSTRACT: (nigeria OR lagos OR abuja)	31,175
Total	#1 AND #2 AND #3 AND #4 AND 2005-2018	63
Cochrane Library		
Variable 1	(electronic medical records OR electronic health records OR digital health OR health information systems OR health information technology OR e health OR ehealth OR e-health):ti,ab,kw	24,229
Variable 2	(effect OR effects OR effectiveness OR efficiency OR efficacy OR efficient OR benefit OR benefits):ti,ab,kw	849,947
Variable 3	(maternal health OR child health OR maternity OR infant OR mother):ti,ab,kw	77,029
Variable 4	(nigeria OR lagos OR abuja):ti,ab,kw	1,122
Total	#1 AND #2 AND #3 AND #4 AND 01/01/2005-31/12/2018	14
PubMed		
Variable 1	(electronic medical records[Title/Abstract] OR electronic health records[Title/Abstract] OR digital health[Title/Abstract] OR health information systems[Title/Abstract] OR health information technology[Title/Abstract] OR e health[Title/Abstract] OR ehealth[Title/Abstract] OR e-health[Title/Abstract])	20,927
Variable 2	(effect[Title/Abstract] OR effects[Title/Abstract] OR effectiveness[Title/Abstract] OR efficiency[Title/Abstract] OR efficacy[Title/Abstract] OR efficient[Title/Abstract] OR benefit[Title/Abstract] OR benefits[Title/Abstract])	3,715,612
Variable 3	(maternal health[Title/Abstract] OR child health[Title/Abstract] OR maternity[Title/Abstract] OR infant[Title/Abstract] OR mother[Title/Abstract])	132,080
Variable 4	(nigeria[Title/Abstract] OR lagos[Title/Abstract] OR abuja[Title/Abstract])	16,483
Total	#1 AND #2 AND #3 AND #4 AND 01/01/2005-31/12/2018	2
EBSCO		
Variable 1	Title/Abstract/Subject Terms: electronic medical records OR electronic health records OR digital health OR health information systems OR health information technology OR e health OR ehealth OR e-health	154,448

Variable 2	Title/Abstract/Subject Terms: effect OR effects OR effectiveness OR efficiency OR efficacy OR efficient OR benefit OR benefits	13,877,306
Variable 3	Title/Abstract/Subject Terms: maternal health OR child health OR maternity OR infant OR mother	974,986
Variable 4	Title/Abstract/Subject Terms: nigeria OR lagos OR abuja	181,136
Total	#1 AND #2 AND #3 AND #4 AND 01/01/2005-31/12/2018	9
MEDLINE		
Variable 1	TOPIC/ABSTRACT:(electronic medical records OR electronic health records OR digital health OR health information systems OR health information technology OR e health OR ehealth OR e-health)	188,795
Variable 2	TOPIC/ABSTRACT: (effect OR effects OR effectiveness OR efficiency OR efficacy OR efficient OR benefit OR benefits)	4,743,172
Variable 3	TOPIC/ABSTRACT:(maternal health OR child health OR maternity OR infant OR mother)	649,506
Variable 4	TOPIC/ABSTRACT: (nigeria OR lagos OR abuja)	19,482
Total	#1 AND #2 AND #3 AND #4 AND 2005-2018	62

Database	Search strategy	Hits
Web of Science	RQ2.1: What cost outcomes lessons that can be learned from the digital health experiences of high income countries?	
Variable 1	TOPIC/ABSTRACT: (electronic medical records OR electronic health records OR digital health OR health information systems OR health information technology OR e health OR ehealth OR e-health) [REVIEW]	19,102
Variable 2	TOPIC/ABSTRACT: (cost OR costs OR savings OR cost benefits OR losses OR economic OR economically OR financing OR financial OR finance) [REVIEW]	136,051
Variable 3	TOPIC/ABSTRACT: (high income countries OR developed countries OR western countries OR europe OR australia OR us OR united states OR uk OR united kingdom OR Canada) [REVIEW]	101,562
Variable 4	TOPIC/ABSTRACT: (maternal health OR child health OR maternity OR infant OR mother) [REVIEW]	37,321
Variable 5	TOPIC/ABSTRACT: (systematic review OR systematic overview OR scoping review OR meta-analysis OR rapid review OR scoping review OR state-of-the-art review) [REVIEW]	335,641
Total	#1 AND #2 AND #3 AND #4 AND #5 2005-2018	124
Cochrane Library		

Variable 1	(electronic medical records OR electronic health records OR digital health OR health information systems OR health information technology OR e health OR ehealth OR e-health) [REVIEW]:ti,ab,kw	1,653
Variable 2	(cost OR costs OR savings OR cost benefits OR losses OR economic OR economically OR financing OR financial OR finance) [REVIEW]:ti,ab,kw	2,328
Variable 3	(high income countries OR developed countries OR western countries OR europe OR australia OR us OR united states OR uk OR united kingdom OR Canada) [REVIEW]:ti,ab,kw	1,806
Variable 4	(maternal health OR child health OR maternity OR infant OR mother) [REVIEW]:ti,ab,kw	1,682
Variable 5	(systematic review OR systematic overview OR scoping review OR meta-analysis OR rapid review OR scoping review OR state-of-the-art review) [REVIEW]:ti,ab,kw	3,838
Total	#1 AND #2 AND #3 AND #4 AND #5 AND 01/01/2005-31/12/2018	77
PubMed		
Variable 1	(electronic medical records[Title/Abstract] OR electronic health records[Title/Abstract] OR digital health[Title/Abstract] OR health information systems[Title/Abstract] OR health information technology[Title/Abstract] OR e health[Title/Abstract] OR ehealth[Title/Abstract] OR e-health[Title/Abstract]) [REVIEW]	1,953
Variable 2	(cost[Title/Abstract] OR costs[Title/Abstract] OR savings[Title/Abstract] OR cost benefits[Title/Abstract] OR losses[Title/Abstract] OR economic[Title/Abstract] OR economically[Title/Abstract] OR financing[Title/Abstract] OR financial[Title/Abstract] OR finance[Title/Abstract]) [REVIEW]	74,738
Variable 3	(high income countries[Title/Abstract] OR developed countries[Title/Abstract] OR western countries[Title/Abstract] OR europe[Title/Abstract] OR australia[Title/Abstract] OR us[Title/Abstract] OR united states[Title/Abstract] OR uk[Title/Abstract] OR united kingdom[Title/Abstract] OR Canada[Title/Abstract]) [REVIEW]	85,390
Variable 4	(maternal health[Title/Abstract] OR child health[Title/Abstract] OR maternity[Title/Abstract] OR infant[Title/Abstract] OR mother[Title/Abstract]) [REVIEW]	16964
Variable 5	(systematic review[Title/Abstract] OR systematic overview[Title/Abstract] OR scoping review[Title/Abstract] OR meta-analysis[Title/Abstract] OR rapid review[Title/Abstract] OR scoping review[Title/Abstract] OR state-of-the-art review[Title/Abstract]) [REVIEW]	109,587
Total	#1 AND #2 AND #3 AND #4 AND #5 AND 01/01/2005-31/12/2018	0
EBSCO		
Variable 1	Title/Abstract/Subject Terms: electronic medical records OR electronic health records OR digital health OR health information systems OR health information technology OR e health OR ehealth OR e-health [REVIEW]	10,898
Variable 2	Title/Abstract/Subject Terms: cost OR costs OR savings OR cost benefits OR losses OR economic OR economically OR financing OR financial OR finance [REVIEW]	274,309

Variable 3	Title/Abstract/Subject Terms: high income countries OR developed countries OR western countries OR europe OR australia OR us OR united states OR uk OR united kingdom OR Canada [REVIEW]	730,115
Variable 4	Title/Abstract/Subject Terms: maternal health OR child health OR maternity OR infant OR mother [REVIEW]	93,523
Variable 5	Title/Abstract/Subject Terms: systematic review OR systematic overview OR scoping review OR meta-analysis OR rapid review OR scoping review OR state-of-the-art review [REVIEW]	147,374
Total	#1 AND #2 AND #3 AND #4 AND #5 AND 01/01/2005-31/12/2018	5
MEDLINE		
Variable 1	TOPIC/ABSTRACT: (electronic medical records OR electronic health records OR digital health OR health information systems OR health information technology OR e health OR ehealth OR e-health) [REVIEW]	24,360
Variable 2	TOPIC/ABSTRACT: (cost OR costs OR savings OR cost benefits OR losses OR economic OR economically OR financing OR financial OR finance) [REVIEW]	140,976
Variable 3	TOPIC/ABSTRACT: (high income countries OR developed countries OR western countries OR europe OR australia OR us OR united states OR uk OR united kingdom OR Canada) [REVIEW]	121,358
Variable 4	TOPIC/ABSTRACT: (maternal health OR child health OR maternity OR infant OR mother) [REVIEW]	68,717
Variable 5	TOPIC/ABSTRACT: (systematic review OR systematic overview OR scoping review OR meta-analysis OR rapid review OR scoping review OR state-of-the-art review) [REVIEW]	163,217
Total	#1 AND #2 AND #3 AND #4 AND #5 2005-2018	129

Appendix 3 – Logic model findings

Article	Findings	Pathway
McNabb et al., 2015	mHealth intervention.	A1
McNabb et al., 2015	Community Health Extension Workers and supervisors in Primary Health Centres were trained to use the mobile app.	B1
McNabb et al., 2015	Participants gave verbal consent to participate in the study	B2
McNabb et al., 2015	A quality score consisting of technical and counselling elements was developed.	B3
McNabb et al., 2015	Effectiveness was assessed by comparing scores from client exit interviews collected at baseline and one year after the intervention at endline.	B4
McNabb et al., 2015	A baseline and endline client exit interview tool was adapted from the Measure DHS tool used for service provision assessment.	B5
McNabb et al., 2015	Data collectors were trained to administer the exit interviews at baseline and endline.	B6
McNabb et al., 2015	Interviewers visited sites for and conducted interviews on as many ANC days as was necessary to reach the individual site target.	B7
McNabb et al., 2015	The mHealth project was implemented.	B8
McNabb et al., 2015	At baseline, HCWs gave unstructured health talks prior to seeing individual clients for ANC days.	B9
McNabb et al., 2015	The mobile app provided decision support functionality for all 25 quality attributes.	C1
McNabb et al., 2015	Standardized health counselling messages were introduced through this intervention and have the potential for affecting positive change in health behaviours that can affect maternal and child health outcomes.	C2
McNabb et al., 2015	The quality score increased at baseline and at endline, with the most significant improvements related to the ANC and health counselling domains.	D1
McNabb et al., 2015	The intervention seemed to have a particularly strong effect on counselling provided by the CHEWs.	D2
McNabb et al., 2015	Improved quality scores related to the frequency at which CHEWs performed more technical aspects of care, such as measuring blood pressure, obtaining blood or urine samples, and certain physical examination screenings for signs of preeclampsia.	D3
McNabb et al., 2015	m4Change (mHealth) intervention was in fact associated with higher quality of ANC scores, with these improvements observed in multiple domains of care.	E1
McNabb et al., 2015	Assessed a project that was implemented in real conditions of health facility operations in Nigeria, not based on assumptions or modelling	E2
McNabb et al., 2015	Mapped the effects of a provider job aid (mHealth application on the overall quality of ANC services and client satisfaction in Nigeria	E3
McNabb et al., 2015	Aimed to improve the literature base, in particular relation to the Nigerian context	E4
Odetola & Okanlawon, 2014	mHealth nursing intervention (educational training for nurses to use mobile health)	A1
Odetola & Okanlawon, 2014	Participants gave consent to participate in the study.	B1
Odetola & Okanlawon, 2014	A thoroughly validated self-developed 25-item questionnaire was pre-tested and validated at Cronbach's Coefficient of 0.8.	B2
Odetola & Okanlawon, 2014	The data was collected over a period of 11 months among nurses who were randomly assigned into experimental and control groups.	B3

Odetola & Okanlawon, 2014	The level of knowledge about m-health nursing intervention was calculated and compared statistically using chi-square at baseline	B4
Odetola & Okanlawon, 2014	Mean values were computed in both experimental and control groups with $p < 0.05$	B5
Odetola & Okanlawon, 2014	Nurses' professional background's influence was explored on the variables to determine any significant relationship	B6
Odetola & Okanlawon, 2014	Nurses acquired knowledge of m-health's effectiveness in healthcare practice.	C1
Odetola & Okanlawon, 2014	Most nurses had neither heard about nor seen m-health nursing intervention in use prior to the study.	D1
Odetola & Okanlawon, 2014	Results after 3 months of the nursing intervention (P ₁) revealed an appreciable improvement in the level of knowledge with mobile health nursing.	D2
Odetola & Okanlawon, 2014	Perception about mobile health effectiveness among the experimental group with a similar trend among the control group as well revealing high level of significance for mobile health nursing and perception of mobile health.	D3
Odetola & Okanlawon, 2014	Repeated measures ANOVA carried out revealed a significant difference in the mean scores in knowledge of m-health	D4
Odetola & Okanlawon, 2014	The formulated hypothesis that stated that there would not be any significant difference in knowledge was failed to be accepted at P ₁ but accepted at P ₂ .	D5
Odetola & Okanlawon, 2014	Major findings thematically revealed network/service failure, inconsistent financial support by the government, and policy instability.	D6
Odetola & Okanlawon, 2014	No significant relationship between all nurses' professional backgrounds and their knowledge of m-health ($p > 0.05$) at baseline, P ₁ and P ₂ levels was observed.	D7
Odetola & Okanlawon, 2014	There was no significant relationship between all nurses' professional backgrounds and their perception of effectiveness of mobile health intervention ($p > 0.05$) at baseline, P ₁ and P ₂ levels.	D8
Odetola & Okanlawon, 2014	Perceived effectiveness of m-health intervention among the Community Health Nurses in the rural communities despite all the identified barriers.	E1
Odetola & Okanlawon, 2014	m-health would be more effective in urban areas where all the barriers are controllable.	E2
Obasola & Mabawonku, 2018	e-health and m-health interventions	A1
Obasola & Mabawonku, 2018	1001 mothers who were attending maternity clinics at Nine public health facilities in Ondo (4), Imo (1), Kaduna (2) and Gombe (2) States were purposively selected for the descriptive survey.	B1
Obasola & Mabawonku, 2018	A questionnaire and focus group discussion (FGD) guide were used to elicit information from mothers involved in ICT based projects in the study locations.	B2
Obasola & Mabawonku, 2018	The questionnaire for the study was developed based on clues from the UTAUT scale for measuring perceived usefulness of an information system.	B3
Obasola & Mabawonku, 2018	The questionnaire was pretested, and the reliability coefficient calculated using Cronbach Alpha was 0.86.	B4
Obasola & Mabawonku, 2018	Research assistants who could speak the local languages were employed for the FGD sessions which were recorded using a mobile device.	B5
Obasola & Mabawonku, 2018	Data collection spanned over nine months.	B6
Obasola & Mabawonku, 2018	Ethical approval was obtained from the University of Ibadan Ethics Committee.	B7
Obasola & Mabawonku, 2018	Informed consent of the participants was obtained.	B8

Obasola & Mabawonku, 2018	The quantitative data were analysed using descriptive statistics, While the qualitative data were transcribed into English and content-analysed.	B9
Obasola & Mabawonku, 2018	Mothers' perceived usefulness of ICT and maternal and child health (MCH) information disseminated using ICT in Nigeria was positive.	C1
Obasola & Mabawonku, 2018	The mothers indicated that phone and radio were the most useful of all ICT tools.	C2
Obasola & Mabawonku, 2018	The perception of the mothers on mobile phones and radio was positive but that of the computer was negative	D1
Obasola & Mabawonku, 2018	The quantitative data revealed improved knowledge about health issues surrounding pregnancy and childbirth (97.3%). The mothers were of the view that the use of ICT disseminated MCH information helped them to stay healthy in pregnancy (94.6%)	D2
Obasola & Mabawonku, 2018	Results from the FGD sessions with the mothers in Imo State revealed a positive perception towards the Internet as important source of MCH information and that it provided the opportunity for them to access health information at their convenience.	D3
Obasola & Mabawonku, 2018	Findings from the FGD in Ondo, Gombe and Kaduna States were different, mothers in the three states indicated a positive preference for mobile phones because of its relevance in meeting specific health information needs (especially during emergencies).	D4
Obasola & Mabawonku, 2018	The findings from mothers' responses during the FGD sessions also showed that some mothers were of the view that, with the exception of interactive radio or television programmes that incorporate feedback through phone calls, MCH information from radio and television was usually limited. They opined that, it will be better to have more interactive TV or radio programmes in different dialects to provide (pregnant women) more opportunities to clarify issues about MCH.	D5
Obasola & Mabawonku, 2018	Mothers use ICT to receive maternal health information and adopt MCH information promoted through ICT once they are convinced that it will help to improve their health.	E1

Participant Consent Form

A feasibility Study of EMR implementation in Nigerian Primary Healthcare (SERAPH)

Name of Researcher: Taiwo Adedeji, University of Portsmouth

I confirm that I have read the information sheet dated 25/04/2019 (version 1.2) for this study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. *

Yes

I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason. *

Yes

I understand that the information collected from me will be used to support other research in the future, and may be shared anonymously with other researchers. *

Yes

My gender is: *

- Male
- Female

My age group is: *

- 18-24
- 25-34
- 35-44
- 45-54
- 54-65
- Over 65

I participate regularly in health service delivery and health records. *

- Yes

My profession is: *

- Medical Officer of Health
- Doctor
- Nurse
- Midwife
- Pharmacist
- Community Health Officer (CHO)
- Community Health Extension Worker (CHEW)
- Monitoring & Evaluation Officer (M & E)
- Health Information Officer (HIO)
- Other:

My speciality/discipline is:

Seen the Minor Ailment
.....

Appendix 5 – Interview guide

Medical Officer of Health (MOH)/Doctor/Head of Nursing (HN)/Community Health Head of Unit (CHH)/Head of Health Information Management (HHIM)

1. What are your reasons for implementing an EMR?
2. What is your vision for the EMR?
3. What are your goals and expectations for the EMR?
 - a. In relation to quality of care
 - b. In relation to clinic efficiency and cost savings
 - c. Patient safety
 - d. Other goals/expectation
4. What skills and resources does your organisation have that make you believe the project will be successful?
5. Describe your leadership and communication styles.
6. Describe your understanding of what will be needed for the EMR implementation
 - a. How did you gain this understanding?
7. Describe the steps you have taken to prepare for the EMR
8. Describe your action plan for implementing the EMR. Please include the following:
 - a. What milestones you have identified
 - b. Plans for addressing challenges that may arise
 - c. Who was key in identifying the milestones and plans to reach them?
9. How have you prepared your staff for the implementation process? What has been their reaction?
10. What incentives have been discussed or are being planned for staff for implementation?
11. What do you feel will be the key challenges to implementation?
12. Who do you feel will be the key facilitators to implementation?
13. Describe the desired impact of the EMR on the organisation.
14. Describe the areas where you think workflow will need to be addressed (lab results, prescription refills, tracking referrals etc)

Members of the guiding team

1. Why is your organisation implementing an EMR?
2. What is the organisation's vision for the EMR?
3. What are your organisation's goals and expectations for the EMR?
 - a. Specifically in relation to quality of care
 - b. Efficiency and cost reduction
 - c. Patient safety
 - d. Other issues
4. What is the leadership style of your MOH/Doctor/HN?
5. How do you describe the effectiveness of his/her leadership style?
6. Describe how you communicate with the MOH/Doctor/HN
7. Describe your role in the organisation
8. What skills and resources does your organisation have that make you believe the project will be successful?

9. How has the EMR project been presented to the staff? What discussions have been held? How has this information been shared/disseminated?
10. What is your perception of the consequences of the success or failure of this project?
11. Describe your organisation's action plan for implementing the EMR. Please include the following:
 - a. What milestones you have identified
 - b. Plans for addressing challenges that may arise
 - c. Who was key in identifying the milestones and plans to reach them?
12. How have you prepared your staff for the implementation process? What has been their reaction?
13. What do you feel will be the key challenges to implementation?
14. What do you feel will be the key facilitators to implementation?
15. Is front-line staff aware of the implementation plan and do they have the same perception of the important impact of the implementation on the organisation?
16. Describe the areas where you think workflow will need to be addressed (lab results, prescription refills, tracking referrals etc.)

Front-line staff

1. What is the leadership style of your MOH/Doctor/HN
2. Describe the effectiveness of the leadership style
3. How do you communicate with the MOH/Doctor/HN
4. Talk about the EMR project. What do you understand about the system, the implementation process and expectations for you? Can you describe the action plan for implementation?
5. How will the EMR implementation impact your job?
6. What are your organisation's goals and expectations for the EMR?
7. How important do you feel the EMR project is to you and your job?
8. How has the EMR project been presented to the staff? What discussions have been held? How has this information been shared/disseminated?
9. What is your perception of the consequences of the success or failure of this project?
10. Describe your action plan for implementing the EMR. Please include the following:
 - a. What milestones you have identified
 - b. Plans for addressing challenges that may arise
11. How has your organisation prepared you for the implementation process? What has been your reaction?
12. What incentives do you have for implementing the EMR?
13. What do you feel will be the key challenges to implementation?
14. What do you feel will be the key facilitators to implementation?
15. Describe the areas where you have the most difficulty with workflow (lab results, prescription refills, tracking referrals etc.)

Appendix 6 – Favourable ethics opinion



FAVOURABLE ETHICAL OPINION

Study Title: A feasibility Study of EMR implementation in NigeriAn Primary Healthcare

Reference Number: **TECH2019-T.A-01**

Date submitted: 25th April 2019

Thank you for submitting your application to the Faculty of Technology Ethics Committee.

I am pleased to inform you that the Faculty of Technology Ethics Committee was content to grant favourable ethical opinion of the above research on the basis described in the submitted documents listed at Annex A, and subject to standard general conditions (*See Annex B*).

Please note that the favourable opinion of the Faculty of Technology Ethics Committee does not grant permission or approval to undertake the research/ work. Management permission or approval must be obtained from any host organisation, including the University of Portsmouth or supervisor, prior to the start of the study.

Wishing you every success in your research

A handwritten signature in black ink that reads 'Jovana Radulovic'. The signature is written in a cursive style and is positioned above a horizontal line.

Jovana Radulovic

Vice Chair, Faculty of Technology Ethics Committee

Annexes

A - Documents reviewed

B - After ethical review

ANNEX A Documents reviewed

The documents ethically reviewed for this application

<i>Document</i>	<i>Version</i>	<i>Date</i>
Application form	1.1	14.04.2019
Participant Information Sheet	1.1a	14.04.2019
Consent form	1.1	14.04.2019

Peer Review		14.04.2019
Survey Instrument	1.1	14.04.2019
Interview/Non-Participant Observation) Questions	1.1a	14.04.2019

ANNEX B - After ethical review

1. This Annex sets out important guidance for those with a favourable opinion from a University of Portsmouth Ethics Committee. Please read the guidance carefully. A failure to follow the guidance could lead to the committee reviewing and possibly revoking its opinion on the research.

2. It is assumed that the work will commence within 1 year of the date of the favourable ethical opinion or the start date stated in the application, whichever is the latest.

3. The work must not commence until the researcher has obtained any necessary management permissions or approvals – this is particularly pertinent in cases of research hosted by external organisations. The appropriate head of department should be aware of a member of staff's plans.

4. If it is proposed to extend the duration of the study beyond that stated in the application, the Ethics Committee must be informed.

5. Any proposed substantial amendments must be submitted to the Ethics Committee for review. A substantial amendment is any amendment to the terms of the application for ethical review, or to the protocol or other supporting documentation approved by the Committee that is likely to affect to a significant degree:

- (a) the safety or physical or mental integrity of participants
- (b) the scientific value of the study
- (c) the conduct or management of the study.

5.1 A substantial amendment should not be implemented until a favourable ethical opinion has been given by the Committee.

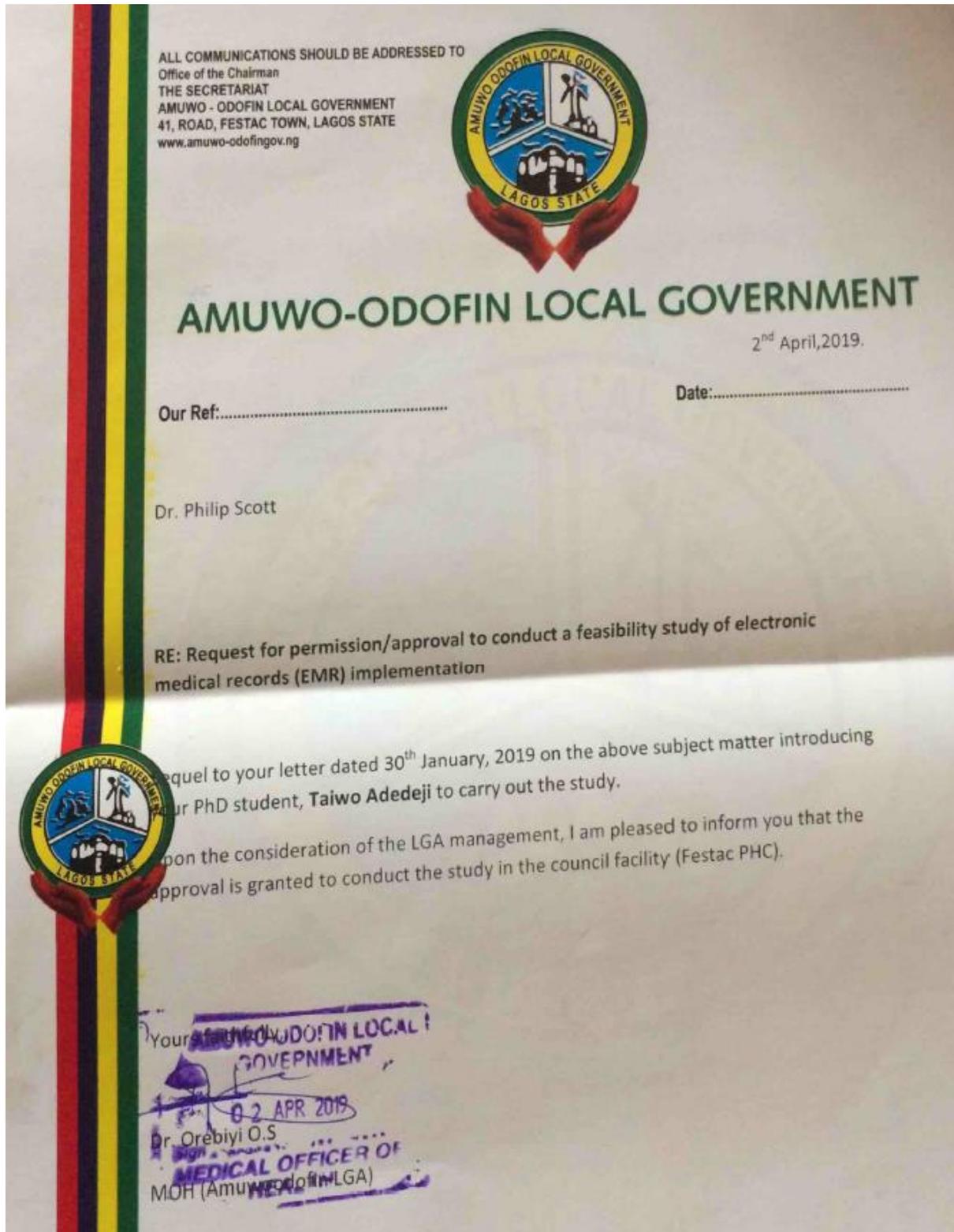
6. At the end of the work a final report should be submitted to the ethics committee. A template for this can be found on the University Ethics webpage.

7. Researchers are reminded of the University's commitments as stated in the [Concordat to Support Research Integrity](#) viz:

- maintaining the highest standards of rigour and integrity in all aspects of research
- ensuring that research is conducted according to appropriate ethical, legal and professional frameworks, obligations and standards
- supporting a research environment that is underpinned by a culture of integrity and based on good governance, best practice and support for the development of researchers
- using transparent, robust and fair processes to deal with allegations of research misconduct should they arise
- working together to strengthen the integrity of research and to reviewing progress regularly and openly.

8. In ensuring that it meets these commitments the University has adopted the [UKRIO Code of Practice for Research](#). Any breach of this code may be considered as misconduct and may be investigated following the University [Procedure for the Investigation of Allegations of Misconduct in Research](#). Researchers are advised to use the [UKRIO checklist](#) as a simple guide to integrity.

Appendix 7 – Approval letter



Appendix 8 – System evaluation

Participant 1 - H10



EMR User Survey

The purpose of this survey is to obtain feedback on the EMR system and how well it is meeting your needs. Results will be compared with the initial readiness assessment data as a benchmark and used to identify areas in need of improvement.

Please complete this survey.

Concerning our recent EMR implementation, check the column that most closely describes how you feel about each of the following statements:	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. EMR has increased overall efficiency.	✓				✓
2. Computerised alerts and reminders are annoying.					✓
3. Our patients are OK with our use of EMR.	✓				
4. EMR improves my personal productivity.	✓				
5. EMR is difficult to use.				✓	
6. Use of EMR in front of patients is depersonalising.					
7. EMR is not as accurate or complete as paper records.					✓
8. EMR improves quality and patient safety.	✓				
9. A first step toward a successful EMR is addressing workflow and process changes.	✓				
10. We are in an age where we must exchange data electronically with others. EMR helps us do this.	✓				
11. Health care is too complex anymore without access to clinical decision support provided by EMR.		✓			
12. EMR are not as secure as paper records.					✓
13. EMR can have unintended consequences if we don't apply professional judgment in its use.			✓		
Please rate the following concerning the EMR:	Worse than Expected	Poor	Acceptable	Good	Better than Expected
a. Training			✓		
b. Response time				✓	
c. Dependability			✓		
d. Technical support			✓		
e. Ease of use				✓	



What is your job title?

- MOH
- Doctor
- Nurse Practitioner
- Midwife
- Monitoring & Evaluation Officer
- Community Health Officer
- Community Health Extension Worker
- Health Information Officer
- Other (please specify): Health Information officer / HI power

What is your gender?

- Male
- Female

How many years have you worked at this PHC? 0-5 years

Participant 2 - HIO



EMR User Survey

The purpose of this survey is to obtain feedback on the EMR system and how well it is meeting your needs. Results will be compared with the initial readiness assessment data as a benchmark and used to identify areas in need of improvement.

Please complete this survey.

Concerning our recent EMR implementation, check the column that most closely describes how you feel about each of the following statements:	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. EMR has increased overall efficiency.		✓			
2. Computerised alerts and reminders are annoying.	✓				
3. Our patients are OK with our use of EMR.		✓			
4. EMR improves my personal productivity.		✓			✓
5. EMR is difficult to use.					
6. Use of EMR in front of patients is depersonalising.		✓			
7. EMR is not as accurate or complete as paper records.	✓				
8. EMR improves quality and patient safety.	✓				
9. A first step toward a successful EMR is addressing workflow and process changes.	✓				
10. We are in an age where we must exchange data electronically with others. EMR helps us do this.		✓			
11. Health care is too complex anymore without access to clinical decision support provided by EMR.	✓				
12. EMR are not as secure as paper records.					✓
13. EMR can have unintended consequences if we don't apply professional judgment in its use.		✓			
Please rate the following concerning the EMR:	Worse than Expected	Poor	Acceptable	Good	Better than Expected
a. Training					✓
b. Response time			✓		
c. Dependability				✓	
d. Technical support					✓
e. Ease of use					



What is your job title?

- MOH
- Doctor
- Nurse Practitioner
- Midwife
- Monitoring & Evaluation Officer
- Community Health Officer
- Community Health Extension Worker
- Health Information Officer *Aspwers*
- Other (please specify): _____

What is your gender?

- Male
- Female

How many years have you worked at this PHC? *2.7* years

Participant 3 - Nurse



EMR User Survey

The purpose of this survey is to obtain feedback on the EMR system and how well it is meeting your needs. Results will be compared with the initial readiness assessment data as a benchmark and used to identify areas in need of improvement.

Please complete this survey.

Concerning our recent EMR implementation, check the column that most closely describes how you feel about each of the following statements:	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. EMR has increased overall efficiency.		✓			
2. Computerised alerts and reminders are annoying.			✓		
3. Our patients are OK with our use of EMR.		✓			
4. EMR improves my personal productivity.	✓				
5. EMR is difficult to use.				✓	
6. Use of EMR in front of patients is depersonalising.				✓	
7. EMR is not as accurate or complete as paper records.					✓
8. EMR improves quality and patient safety.	✓				
9. A first step toward a successful EMR is addressing workflow and process changes.		✓			
10. We are in an age where we must exchange data electronically with others. EMR helps us do this.		✓			
11. Health care is too complex anymore without access to clinical decision support provided by EMR.		✓			
12. EMR are not as secure as paper records.		✓			
13. EMR can have unintended consequences if we don't apply professional judgment in its use.			✓	✓	
Please rate the following concerning the EMR:	Worse than Expected	Poor	Acceptable	Good	Better than Expected
a. Training				✓	
b. Response time				✓	
c. Dependability				✓	
d. Technical support				✓	
e. Ease of use				✓	



What is your job title?

- MOH
- Doctor
- Nurse Practitioner
- Midwife
- Monitoring & Evaluation Officer
- Community Health Officer
- Community Health Extension Worker
- Health Information Officer
- Other (please specify): _____

What is your gender?

- Male
- Female

How many years have you worked at this PHC? 2 years

Participant 4 — Doctor



EMR User Survey

The purpose of this survey is to obtain feedback on the EMR system and how well it is meeting your needs. Results will be compared with the initial readiness assessment data as a benchmark and used to identify areas in need of improvement.

Please complete this survey.

Concerning our recent EMR implementation, check the column that most closely describes how you feel about each of the following statements:	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. EMR has increased overall efficiency.	✓				
2. Computerised alerts and reminders are annoying.					✓
3. Our patients are OK with our use of EMR.	✓				
4. EMR improves my personal productivity.	✓				
5. EMR is difficult to use.					✓
6. Use of EMR in front of patients is depersonalising.					✓
7. EMR is not as accurate or complete as paper records.					✓
8. EMR improves quality and patient safety.	✓				
9. A first step toward a successful EMR is addressing workflow and process changes.	✓				
10. We are in an age where we must exchange data electronically with others. EMR helps us do this.	✓				
11. Health care is too complex anymore without access to clinical decision support provided by EMR.					✓
12. EMR are not as secure as paper records.					✓
13. EMR can have unintended consequences if we don't apply professional judgment in its use.					✓
Please rate the following concerning the EMR:	Worse than Expected	Poor	Acceptable	Good	Better than Expected
a. Training					✓
b. Response time					✓
c. Dependability					✓
d. Technical support					✓
e. Ease of use					✓



What is your job title?

- MOH
- Doctor
- Nurse Practitioner
- Midwife
- Monitoring & Evaluation Officer
- Community Health Officer
- Community Health Extension Worker
- Health Information Officer
- Other (please specify): _____

What is your gender?

- Male
- Female

How many years have you worked at this PHC? 14 years

Participant 5 — HIO



EMR User Survey

The purpose of this survey is to obtain feedback on the EMR system and how well it is meeting your needs. Results will be compared with the initial readiness assessment data as a benchmark and used to identify areas in need of improvement.

Please complete this survey.

Concerning our recent EMR implementation, check the column that most closely describes how you feel about each of the following statements:	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. EMR has increased overall efficiency.					
2. Computerised alerts and reminders are annoying.					✓
3. Our patients are OK with our use of EMR.		✓			
4. EMR improves my personal productivity.	✓				
5. EMR is difficult to use.					✓
6. Use of EMR in front of patients is depersonalising.				✓	
7. EMR is not as accurate or complete as paper records.					
8. EMR improves quality and patient safety.	✓				
9. A first step toward a successful EMR is addressing workflow and process changes.		✓			
10. We are in an age where we must exchange data electronically with others. EMR helps us do this.	✓				
11. Health care is too complex anymore without access to clinical decision support provided by EMR.			✓	Neutral	
12. EMR are not as secure as paper records.				✓	
13. EMR can have unintended consequences if we don't apply professional judgment in its use.		✓			
Please rate the following concerning the EMR:	Worse than Expected	Poor	Acceptable	Good	Better than Expected
a. Training					
b. Response time				✓	
c. Dependability				✓	✓
d. Technical support				✓	
e. Ease of use				✓	✓



What is your job title?

- MOH
- Doctor
- Nurse Practitioner
- Midwife
- Monitoring & Evaluation Officer
- Community Health Officer
- Community Health Extension Worker
- Health Information Officer
- Other (please specify): _____

What is your gender?

- Male
- Female

How many years have you worked at this PHC? 6 months ~~years~~

Participant 6 - HIO



EMR User Survey

The purpose of this survey is to obtain feedback on the EMR system and how well it is meeting your needs. Results will be compared with the initial readiness assessment data as a benchmark and used to identify areas in need of improvement.

Please complete this survey.

Concerning our recent EMR implementation, check the column that most closely describes how you feel about each of the following statements:	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. EMR has increased overall efficiency.		✓			
2. Computerised alerts and reminders are annoying.			✓		
3. Our patients are OK with our use of EMR.	✓				
4. EMR improves my personal productivity.		✓			
5. EMR is difficult to use.				✓	
6. Use of EMR in front of patients is depersonalising.				✓	
7. EMR is not as accurate or complete as paper records.				✓	
8. EMR improves quality and patient safety.		✓		✓	
9. A first step toward a successful EMR is addressing workflow and process changes.		✓			
10. We are in an age where we must exchange data electronically with others. EMR helps us do this.	✓	✓			
11. Health care is too complex anymore without access to clinical decision support provided by EMR.		✓			
12. EMR are not as secure as paper records.				✓	
13. EMR can have unintended consequences if we don't apply professional judgment in its use.			✓		
Please rate the following concerning the EMR:	Worse than Expected	Poor	Acceptable	Good	Better than Expected
a. Training				✓	
b. Response time				✓	
c. Dependability				✓	
d. Technical support				✓	
e. Ease of use				✓	



What is your job title?

- MOH
- Doctor
- Nurse Practitioner
- Midwife
- Monitoring & Evaluation Officer
- Community Health Officer
- Community Health Extension Worker
- Health Information Officer
- Other (please specify): _____

What is your gender?

- Male
- Female

How many years have you worked at this PHC? 3 years

Participant 7 — HEO



EMR User Survey

The purpose of this survey is to obtain feedback on the EMR system and how well it is meeting your needs. Results will be compared with the initial readiness assessment data as a benchmark and used to identify areas in need of improvement.

Please complete this survey.

Concerning our recent EMR implementation, check the column that most closely describes how you feel about each of the following statements:	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. EMR has increased overall efficiency.		✓			
2. Computerised alerts and reminders are annoying.		✓			
3. Our patients are OK with our use of EMR.		✓			
4. EMR improves my personal productivity.		✓			
5. EMR is difficult to use.					
6. Use of EMR in front of patients is depersonalising.				✓	
7. EMR is not as accurate or complete as paper records.		✓			
8. EMR improves quality and patient safety.		✓		✓	
9. A first step toward a successful EMR is addressing workflow and process changes.		✓			
10. We are in an age where we must exchange data electronically with others. EMR helps us do this.		✓			
11. Health care is too complex anymore without access to clinical decision support provided by EMR.		✓			
12. EMR are not as secure as paper records.				✓	
13. EMR can have unintended consequences if we don't apply professional judgment in its use.				✓	
Please rate the following concerning the EMR:	Worse than Expected	Poor	Acceptable	Good	Better than Expected
a. Training					
b. Response time				✓	
c. Dependability				✓	
d. Technical support				✓	
e. Ease of use					✓



What is your job title?

- MOH
- Doctor
- Nurse Practitioner
- Midwife
- Monitoring & Evaluation Officer
- Community Health Officer
- Community Health Extension Worker
- Health Information Officer
- Other (please specify): _____

What is your gender?

- Male
- Female

How many years have you worked at this PHC? 6 months years

Appendix 9 – Research Ethics Review Checklist

FORM UPR16

Research Ethics Review Checklist



Please include this completed form as an appendix to your thesis (see the Research Degrees Operational Handbook for more information)

Postgraduate Research Student (PGRS) Information		Student ID:	471280
PGRS Name:	Taiwo Adedeji		
Department:	Computing	First Supervisor:	Dr Philip Scott
Start Date: (or progression date for Prof Doc students)	01/02/2018		
Study Mode and Route:	Part-time <input type="checkbox"/>	MPhil <input type="checkbox"/>	MD <input type="checkbox"/>
	Full-time <input checked="" type="checkbox"/>	PhD <input checked="" type="checkbox"/>	Professional Doctorate <input type="checkbox"/>
Title of Thesis:	Realising the benefits of digital health implementation in low- and middle-income countries: Applying Theory of Change in Nigerian primary care		
Thesis Word Count: (excluding ancillary data)	23,945		
<p>If you are unsure about any of the following, please contact the local representative on your Faculty Ethics Committee for advice. Please note that it is your responsibility to follow the University's Ethics Policy and any relevant University, academic or professional guidelines in the conduct of your study</p> <p>Although the Ethics Committee may have given your study a favourable opinion, the final responsibility for the ethical conduct of this work lies with the researcher(s).</p>			
UKRIO Finished Research Checklist:			
(If you would like to know more about the checklist, please see your Faculty or Departmental Ethics Committee rep or see the online version of the full checklist at: http://www.ukrio.org/what-we-do/code-of-practice-for-research/)			
a) Have all of your research and findings been reported accurately, honestly and within a reasonable time frame?	YES <input checked="" type="checkbox"/>	NO <input type="checkbox"/>	
b) Have all contributions to knowledge been acknowledged?	YES <input checked="" type="checkbox"/>	NO <input type="checkbox"/>	
c) Have you complied with all agreements relating to intellectual property, publication and authorship?	YES <input checked="" type="checkbox"/>	NO <input type="checkbox"/>	
d) Has your research data been retained in a secure and accessible form and will it remain so for the required duration?	YES <input checked="" type="checkbox"/>	NO <input type="checkbox"/>	
e) Does your research comply with all legal, ethical, and contractual requirements?	YES <input checked="" type="checkbox"/>	NO <input type="checkbox"/>	
Candidate Statement:			
I have considered the ethical dimensions of the above named research project, and have successfully obtained the necessary ethical approval(s)			
Ethical review number(s) from Faculty Ethics Committee (or from NRES/SCREC):	TECH2019-T.A-01		
If you have not submitted your work for ethical review, and/or you have answered 'No' to one or more of questions a) to e), please explain below why this is so:			
Signed (PGRS):		Date:	02/04/2021