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DESIGNING A DATA EXCHANGE MODEL FOR EPMS AND EDT SYSTEMS IN THE DIRECTORATE OF SPECIAL PROGRAMMES OF THE MINISTRY OF HEALTH AND SOCIAL SERVICES [MOHSS]

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Abstract

Interoperability of health information systems (HIS) is a major challenge in many developing countries and Namibia is no exception (Nengomasha, Abankwah, Uutoni, & Pazvakawamba, 2018). In Namibia, the MoHSS has failed to implement a fully functional integrated HIS, despite continuous support made by numerous donors (Dlodlo & Hamunyela, 2017). As a result, the MoHSS is facing difficulties in integrating these fragmented information systems due to their differences in terms of platform and database structure. Putting in mind the challenges caused by lack of integration, systems interoperability through a model has been identified as a fitting solution which the research aimed to achieve. In order to achieve the research's aim, three objectives were identified. The first objective was to examine EPMS and EDT systems' functional data and compatibility issues. The second objective of this research was to analyse common reports generated from EPMS and EDT systems and the challenges involved in producing a common and single report. The final objective was to determine the processes that are required for EPMS and EDT systems to integrate. To address these objectives, a design science research methodology was applied in the development of the interoperability model. A qualitative data collection methodology was adopted using document analysis of targeted documents and semi-structured interviews with relevant departments of the MoHSS. The data collected through document analysis was analysed using a content analysis approach, whereby a conceptual analysis method was applied. Subsequently, data from semi-structured interviews were analysed using a thematic data analysis approach.

The results show that EPMS and EDT systems are not compatible in terms of syntactic, conceptual, and terminologies. The results also showed that EPMS and EDT systems have few clinical operational discrepancies. The results further indicated that EPMS and EDT systems do not have a common patient identifier, however, the two systems share a wide range of common input data fields, which if shared can be a solution to incompleteness and reporting discrepancies. In terms of ICT infrastructure, EPMS and EDT systems are standalone databases that are hosted on

different networks. Also, most ART facilities do not have internet connections while some have challenges with the network connection.

From a technical perspective, this research emphasises that EPMS and EDT systems can interoperate. The research further, recommends that EPMS and EDT systems can interoperate through adopting an integrated data model known as a canonical model. This technological initiative will allow EPMS and EDT systems to exchange common input data fields by mapping them together to create a single unified view that will help overcome the two systems' heterogeneous nature in terms of conceptual, semantic and syntactic levels.

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List of Acronyms

ANSI	American National Standards Institute
ART	Antiretroviral
DSP	Department of Special Program
DT	Design Theory
EDT	Electronic Dispensing Tool
EPMS	Electronic Patient Management System
HCT	HIV Counselling and Testing
HIMSS	Healthcare Information and Management System Society
HIS	Health Information Systems
HL7	Health Level 7
ICT	Information and Communication Technology
IHE	Integrating the Healthcare Enterprise
IHTSDO	International Health Terminology Standard Development Organisation
IT	Information Technology
LISI	Levels of Information Systems Interoperability
MoHSS	Ministry of Health and Social Services
WHO	World Health Organisation
HEA	Health Enterprise Architecture

HNSF	Health Normative Standard Framework
MoH	Ministry of Health
NDOH	National Department of Health
RHEA	Rwandan Health Enterprise Architecture
RMoH	Rwandan Ministry of Health
RNHIS	Rwandan National Health Information System

Chapter 1: Introduction and Background

1. Introduction

One of the fundamental human rights is the ability to have access to quality healthcare as declared in article 25 of the Universal Human Rights (Ghebreyesus, 2017). However, this vision is restrained by several challenges. One of the challenges is to make good health decisions due to inadequate and poor-quality health information (Nalbandian, 2019). In the past years, numerous donors implemented Health Information Systems (HIS) to help address challenges associated with healthcare, which however did not bear the intended fruits (Dlodlo & Hamunyela, 2017). In many cases, one of the major contributing factors to the downfall of HIS is the inability to adopt one solution that can be implemented and used successfully by different departments and health institutions. Therefore, the use of heterogeneous systems makes it difficult for the healthcare industry to exchange crucial patients' information due to the lack of interoperability (National Strategic Framework for HIV/AIDS (2017).

1.2 Research Background

The MOHSS consists of 67 information systems/databases (Dlodlo & Hamunyela, 2017). These systems/databases are scattered in different directories of the MOHSS in a fragmented and disjointed state (Nengomasha et al., 2018). Furthermore, these HIS are either manual, paper-based, or partially electronic (Dlodlo & Hamunyela, 2017). Even though the MOHSS is supported by 67 systems and databases, there is no guarantee of quality data and patient safety as the data generated from these systems is unreliable (Nengomash et al., 2018). Moreover, there is no directorate that is assigned to manage the 67 HIS of the MOHSS. This has resulted in a lack of up to date HIS strategic plans and policies and lack of HIS growth due to little or no support and political involvement in HIS strengthening (National Strategic Framework for HIV/AIDS (2017).

According to the National Strategic Framework for HIV/AIDS (2017), the MOHSS's HIS is facing challenges. This includes a lack of common patient identification across Health Information Systems, and the differences in terms of system/database platforms and semantics. Similarly, Kapepo and Yashik (2018) also indicate that HIS lacks standardisation due to mismatches in terms of database structures, data types, and set-up. Thus, data exchange among HIS is currently nearly impossible due to the degree of heterogeneity that is associated with HIS (Ndlodlo & Hamunyela 2017). Furthermore, Kapepo and Yashik (2018) and the National Strategic Framework for HIV/AIDS (2017) mention that the poor ICT infrastructure is also impacting the ability of HIS integration as the local/wide area network connection is either inadequate or not available at all.

The RM&E division of the DSP established top priority strategies for 2021/2022 towards address HIS and data challenges, and this is also highlighted in the National Strategic Framework for HIV/AIDS 2017 as:

a) HIS integration and reporting requirements strengthening;
b) Implementation of patients' universal unique identification number;
c) Development of human resources with the required skills in relevant areas; and
d) Advocacy for additional financial resources to strengthen RM&E and HIRD divisions' capacity.

1.3 Problem Statement

Interoperability of Health Information Systems is a major challenge in many developing countries and Namibia is no exception (Nengomasha et al., 2018). In Namibia, the MoHSS has failed to implement a fully functional integrated HIS, despite continuous support made by numerous donors (Dlodlo & Hamunyela, 2017). This is because the development and acquisition of health information systems by the MoHSS and its partners are not harmonised but only driven by individual projects' needs (Ndlodlo & Hamunyela, 2017). As a result, the MoHSS is facing difficulties in integrating these fragmented information systems due to their differences in terms of platform and database structure. Thus, there is a need to develop and implement a standardised and maintainable integrated information system to overcome challenges such as data discrepancies in monthly reports, and data redundancy, and to develop effective data sharing mechanisms among different departments and health institutions.

Although the Directorate of Special Programmes administers several Health Information Systems such as TB and Malaria, this research is solely concerned with the integration of health information systems that deal with the administration of ART patients which are the Electronic Patient Management System (EPMS), and the Electronic Dispensing Tool (EDT). This is because EPMS and EDT systems manage information for the same patients, but they are standalone databases that lack integration, as a result these systems' reporting systems are not reckoning. However, the challenges for EPMS and EDT systems do not influence the reporting systems for the other systems managed by the DSP.

1.5 Research Objectives and Questions

1.5.1 Aim

The overall aim of this research was to design a model that can enable EPMS and EDT systems to interoperate without redesigning their current architectural designs.

Objectives:

a) Examine functional data and compatibility issues of EPMS and EDT systems.

b) Analyse reports being generated from EPMS and EDT systems and the challenges involved in producing a common and single report.

c) Determine processes required for integration of EPMS and EDT systems.

1.5.2 Research Question (s)

The main question of the research is: How can EPMS ad EDT systems interoperate without compromising their current architectural designs?

To address the objectives of the research, the following sub-questions were incorporated:

a) What functional data and compatibility issues need to be resolved to achieve EPMS and EDT systems interoperability?

b) How can the EPMS and EDT systems produce a common report?

c) What processes are required to integrate EPMS and EDT systems?

1.6 Research Methodology

The research adopted a qualitative research approach as the main research strategy. The qualitative research strategy was found suitable to enable the research to explore, investigate, and close examine the "as is" situation of EPMS and EDT systems.

1.6.1 Data Collection

The research used document analysis to collect data from user manuals and data dictionaries as the first form of data collection method. Semi-structured interviews were adopted as the second data collection method whereby eight participants were interviewed. The semi-structured interview participants included selected employees from the DSP, pharmaceutical, and the HIS departments of MoHSS.

1.6.2 Data Analysis

The data that were collected through data analysis and semi-structured interviews were analysed using two qualitative data analysis approaches. Document analysis data were analysed using the content analysis approach. On the other hand, semi-structured interview data were analysed with a thematic data analysis approach. The findings from both content analysis and thematic analysis were compared for cross verification of the overall findings of the research.

1.7 Research Significance

This research provides an interoperability solution in the form a model for EPMS and EDT systems of DSP. The EPMS and EDT systems interoperability model can help the MoHSS to have a solution to its challenges without redesigning the two systems. The researcher believes that EPMS and EDT reengineering might require a lot of funds which the MoHSS does not currently have.

1.8 Ethical Considerations

The researcher obtained ethical clearance from the NUST Research Ethics Committee which permitted the researcher to go forward with the collection of data. Moreover, the researcher also obtained approval for collecting data from the MoHSS, which was obtained from the MoHSS's Research Department.

1.9 Research Limitations

The researcher planned to engage 10 interview participants. However, only 8 participants managed to participate in the study. This is because two participants indicated that they would not be available for data collection due to other work commitments. The MoHSS has DSP, pharmaceutical, and HIS departments in each region. The research decided to conduct interviews with employees of all the relevant departments situated at the head office in Windhoek and this was due to financial constraints as the researcher would have been required to travel to all 14 regions across the country.

1.10 Thesis Outline

The research is organised into five chapters.

a) Chapter one is the research introduction and background. This chapter includes the research's problem statement, the research objectives, research questions, brief research methodology, research significance, ethical considerations, research limitations, and the research outline.

b) Chapter two is the background literature. This chapter contains the research's general definition of HIS-related terminology, concepts and the HIS definitions of these concepts. It also includes ways of achieving interoperability, challenges associated with HIS interoperability, and how to overcome those challenges, HIS interoperability standards, the adoption of E-health interoperability standards, and interoperability related work.

c) Chapter three is about the research methodology. This chapter describes how the research was conducted in terms of the research design, research strategy and the adopted research theory. Furthermore, research sampling, data collection methods, and data analysis approaches are also described in this chapter.

d) Chapter four is on data analysis and findings. This chapter describes two data analysis approaches that were adopted by the research to analyse and interpret the data.

e) Chapter five is the design and development of the EPMS and EDT systems interoperability model. Here, the research highlights the process required for the EPMS and EDT systems to integrate.

f) Chapter six covers the research summary and conclusion.

1.11 Chapter conclusion

The use of health information systems (HIS) is crucial for quality healthcare, patients' safety, and informed decision making. In most cases, the health sector is associated with legacy systems that are fragmented, disjointed, and lack interoperability (Ndlodlo & Hamunyela, 2017). This results in many challenges that include incomplete data and discrepancies in reporting. Unfortunately, this is the reality of the DSP of the MoHSS that deals with the administration of HIV/AIDS data which are captured into two fragmented and disjointed health systems, that is, EPMS and EDT. EPMS and EDT systems' interoperability can enable the DSP to overcome the above-mentioned challenges.

Chapter 2: Literature Review

2.1 Introduction

The literature review chapter presents the HIS and its relevant concepts that are related to systems interoperability. This chapter is outlined as follows: The first section contains the overview of systems that support HIV programmes, general definitions of selected essential terminologies, ways in which interoperability can be achieved, and its challenges. The second section includes HIS standards, how they can be incorporated to achieve interoperability between heterogeneous systems, and the adoption of HIS standards in Africa. Lastly, the third section presents the actual work and studies conducted on HIS system interoperability.

2.2 Overview of HIV systems, HCT, EPMS, and EDT systems in the MOHSS

The HIV Counselling and Testing (HCT) database is intended to capture and store data for clients that have received HIV counselling and testing services. The clients that test HIV positive are then referred for Anti-retroviral Treatment (ART) initiation. Once the patient is put on the ART programme, the details are captured on the Electronic Patient Management system (EPMS), where all the patients' treatment history is captured and stored. After that, patients are required to visit the pharmacy for medication dispensing. At the pharmacy, the medication dispensing process is captured on an Electronic Dispensing Tool (EDT). The HCT system provides the total number of identified HIV positive clients, and the EPM system on the other hand captures data of the patients that are enrolled on ART, while the EDT at the dispensing side captures the records (e.g. next date to collect the treatment, etc.) of patients per facility, district, region or nationally. Missing patient records can be obtained from HCT, EPMS, or EDT systems. Each system has a distinct patient unique identifier, which is generated differently. HCT uses client codes, EPMS uses a unique ART number, and EDT uses the pharmacy number.

In this process alone, some of the patients' information is repeatedly captured in different and fragmented information systems and stored at different locations. These different systems are monitored and controlled by different stakeholders that lack cooperation. As a result, reports generated from these systems are not reckoning due to missing or incomplete patient information, data redundancy, and unreliable patient data.

Looking at the above inconveniences, one would imagine that the ideal solution to this problem would therefore be:

a) Firstly, get counselling and testing services;

b) If the patient tests positive, then forward data to the ART system and subsequently to the EDT system.

Trying to minimise the challenge of missing records that hinder the provision of quality health care to patients is critical as the data will be captured from one system and forwarded to other systems. This might help to control the double-entry of similar data in different systems. On the other hand, when the data is shared, the reports generated from these systems will have more meaning in such a way that the total number of patients that have tested HIV positive will tally with the total number of patients that are linked to care. Lastly, the workload at the facility level will be reduced as unique fields that are specific to that system will be captured. This will make it easier for the admin officers to keep the patients' records up to date, thereby allowing the decision-makers to have access to patients' real-time data.

2.3 Systems Interoperability and Integration

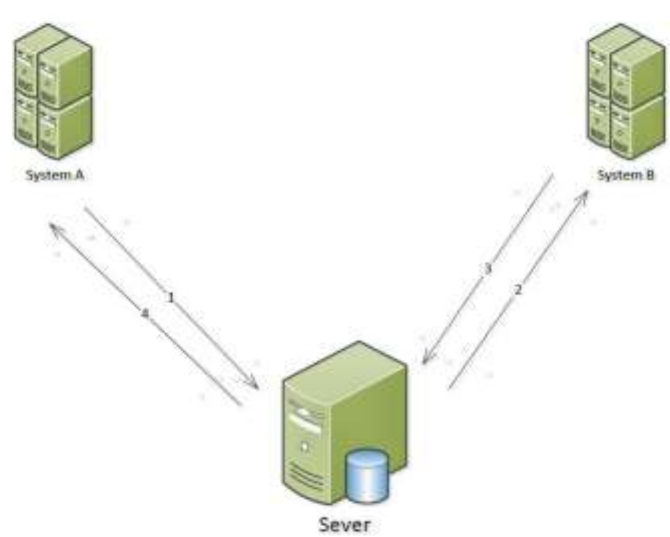
For a clear understanding of the background of this research, it is vital to distinguish between the following two terms: interoperability and integration. According to Roberts (2017, interoperability and integration are used interchangeably when referring to data exchange between systems.

In ICT, Integration is concerned with combining various applications for them to work together as one unit so as to share information in the simplest possible way (Wilder, 2019). For interoperability to be a success, a certain level of integration between systems should first exist. Similarly, according to Roberts (2017), for interoperability to take place there should be integration between the integrated system. This means that integration is part of the interoperability, however, integration does not always need interoperability for it to happen.

Furthermore, integration is commonly used daily when exchanging data that does not require interpretation. For example, communication via emails within or across organisations only requires integration. Interoperability is very crucial in healthcare, and according to Roberts (2017, p. ??), the healthcare industry needs *"immediate access to information that interoperability makes possible allows for both a complete view of the patient (necessary to provide the highest quality care) and the ability to be agile when it comes to complying with requests and reporting requirements".* For interoperability to happen, integration needs to happen first. Similarly, the health information systems in the MoHSS that deal with the administration of ART patients which in this case are the Electronic Patient Management System (EPMS) and the Electronic Dispensing Tool (EDT) systems that work with the administration of the same patient's treatment data but these have different platforms, database structures, and data semantics. Therefore, in this research the focus is solely on enabling systems in one department to interoperate, thus interoperability of systems is the term that is adopted.

Figure 1.2 shows the use case scenario of interoperable systems. The two client systems send and receive information from a central location, which is the main server. These systems receive and send data without a change in data semantics using a single interpreter. In this scenario, the interpreter is acting as a presentation layer that deals with encoding and decoding the syntax to System b.

Figure 2.1: Interoperability process between System A and System B



The data communication and exchange process between the two systems is described below:

1. System A pushes new records or updates existing records on the server
2. a) System B queries the server for the new records and imports them

   b) System B queries for updates or additional information to amend existing records. This step is done concurrently with step 2a
3. System B exports new/updated records to the SQL server
4. System A queries for updated records, then the new and updated records from System B are pulled by System A from the server

2.4 Achieving Systems Interoperability

Over the years, many diverse and distributed information sources have been available in government departments. In most cases, these systems have numerous variances in terms of hardware, software, and data presentation. As a result, the systems are different and disjointed. This is referred to as heterogeneous systems (Shawn et al., 2019). Thus, the exchange of information between these systems has therefore become a crucial factor which can only be achieved through interoperability. Interoperability allows the synchronisation and exchange of data and services between heterogeneous modules or systems regardless of semantic interface and platform variances (Hu, 2017). Therefore, to overcome interoperability between heterogeneous systems, the level of system heterogeneity is reviewed.

Heterogeneity of systems can be categorised into three main groups namely: syntactic, structural, and semantic heterogeneity.

a) Syntactic heterogeneity: This is when data from different data sources is represented differently in terms of data types and formats (Laadhar et al., 2017).

b) Structural heterogeneity: structural heterogeneity describes the data model that the data is represented in (Wang at el., 2019). Similarly, Manhal et al. (2017) describes structural interoperability as a procedural interoperability mechanism that focuses on the design of the data exchange between health information systems and allows the unvarying exchange of data between clinical systems and operational systems, thus preserving the meaning of data.

c) Semantic heterogeneity: This type of heterogeneity occurs when the content of information and its meaning are considered to avoid ambiguity in meaning (Laadhar et al., 2017). However, this is only attainable if the system uses the same interpretation of the information. A semantic layer in interoperability defines the capability of data exchange and the use of various health systems. For semantic heterogeneity to be resolved, data standards should be well defined and structured in a normalised manner that allows the comparisons of data fields so as to ensure a similar meaning of data fields before sharing (Laadhar et al., 2017).

2.5 Semantic Interoperability

In today's world of evolving technology, access to relevant and accurate data is increasingly becoming difficult. Therefore, the best solution is to be able to identify and achieve the level of integration that best fits the systems involved. In healthcare, patient data is captured in different data sources, therefore it is crucial to integrate the patient data so as to preserve the mining of data which is highly recommending for patient care in terms of patients' safety and decision making (Solar, 2017). According to Lehne et al. (2019), semantic interoperability is the best solution for data sharing between heterogeneous systems, especially in healthcare. This is because semantic interoperability provides the ability to have access to complete and accurate data for the right person when it's most needed from different sources as a way to improve quality healthcare (Lehne et al., 2019).

Semantic interoperability is defined as the ability to exchange information between several information systems at a high level, and the ability to use the exchanged information (Bauer at el.,, 2019). Semantic interoperability ensures data sources involved in interoperability have a common understanding of the meaning of the requested data and services (Solar, 2017). During this research, many studies on semantic interoperability covered by many other researchers that were determined to find solutions for effective methods to share and use clinical data across different units in health institutions were reviewed, and these include Sudmanns et al. (2017), El-

Sappagh et al. (2019)and Leroux et al. (2017), Janaswamy (2017). Leroux et al. (2017) and Janaswamy (2017) works will be reviewed below.

According to (Hendrik, 2019). , the heterogeneity of both the data and data models of legacy systems complicates or prevents data integration, standardisation, and interoperability of heterogeneous systems. Leroux et al. (2017) compiled a study on semantic interoperability of clinical data with FHIR resources, whereby the study adopted an Operational Data Model (ODM) to integrate clinical data from numerous data sources. The ODM data model was integrated with FHIR resources that were used to preserve data and its metadata. The ODM data model consists of two main layers, a clinical layer, and the metadata layer. These layers are referenced using a common unique identifier that is used to support data conversion and extraction. On the other hand (Janaswamy, 2017), conducted a study on semantic interoperability and data mapping in HER systems which was aimed at creating a common platform to support mapping of un-normalised data, while enabling semantic integration to promote interoperability. Janaswamy (2017) used programming procedures to analyse data semantics of various heterogeneous systems. Janaswamy (2017) used a hybrid procedure to achieved data mapping and the implemented algorithm was divided into several steps. Janaswamy (2017) also examined the heterogeneous systems to outline the data structures, as well as syntactic and semantics variances. Janaswamy (2017) then used the LOINC database as a reference to compare the codes of attributes with each other. Finally, Janaswamy (2017) created databases and tables with intersectional attributes with a canonical model and concluded that he had succeeded in mapping data for multiple heterogeneous systems by integrating the data into a single database that can be used for analysis and testing.

Apart from the studies on interoperability between heterogeneous systems, some researchers reviewed terminologies that need to be considered on data exchange across different systems, as follows:

a) Ontology

Generally, ontology is a term that is used when you are defining and describing what something means (Luke at el., 2018). In informatics, ontology is the backbone for semantic interoperability as it encourages common grounds among information systems. A foundation of semantic interoperability should be primarily established by explaining the concept of data, information, and knowledge by outlining the relationships and interpretations of data (Bhardwaj et al., 2018). Similarly, the used ontology in semantic interoperability enables flexibility in data integration by allowing it to cope with changes in meaning which can result in ambiguity. Furthermore, the data semantics of an entity that belongs to a particular domain can be accurately and effectively described when the ontology concept is adopted (Kokla &Guilbert, 2020). Ontology can also be useful in addressing consistency and compatibility issues in entities and also in generating a knowledge base (Kokla &Guilbert, 2020). Similarly, Chimalakonda & Nori (2020) indicate that ontology is used in combining the knowledge that humans or machines can make use of to solve problems or when making important decisions. Furthermore, the information should be processed with effective use of the acquired knowledge for great results (Chimalakonda & Nori 2020). Therefore, to achieve semantic interoperability, a common understanding should be perceived across all information systems involved through the application of ontology.

a) Data Semantics

Generally, according to Sankaravelayuthan (2018), semantics is a terminology derived from a Greek word which is used in studying languages and determining their meanings based on individual experiences and backgrounds. However, in terms of information systems, semantics can be defined as “the meaning of data” (Ceravolo at el., 2018). Ramesh and Henderson (2018) on the other hand define data semantics as an old-fashioned approach that is used in studying data and defining the meaning of individual words, or when different words are combined, as well as determining the relationship across the metadata of the database. According to Vidal et al. (2018), data semantics plays an integral role in data integration and systems interoperability, and that being said, heterogeneous systems have different data semantics which are caused by different structures and data sets suitable for these different but related solutions developed by independent parties. This difference in database schemas is referred to as semantic heterogeneity (Jaybal et al., 2018). However, for multiple data sources to interchange data, heterogeneity semantics needs to be reconciled (Liu at el., 2018). Furthermore, Lui (2019) indicates that data semantics assists data fusion from different sources in overcoming and understanding the relationships between different data sets and the structural backgrounds of different systems.

Numerous ways of data semantic heterogeneity classification can be used to solve challenges that might impact data exchange across different systems (Jaybal et al., 2018). Data exchange between heterogeneous systems needs a spotless analysis, to overcome schema and semantic heterogeneity. Furthermore, teminology conflicting which involve attributes names or vocabularies whereby different systems use homonyms (which refers to attributes, field names or standards that share the same name across different systems but are interpreted differently) (EI Hajjamy et al., (2018)). EI Hajjamy et al., (2018) also indicate that naming conflicts involve synonyms which are referred to as attributes that have the same meaning but are named differently. Moreover, EIHajjamy et al. (2018) further discussed the structural conflicts associated with heterogeneous systems. Structural conflicts are further broken down into small groups which involve the design of the database structure, the relationships between the entities and the attributes, the specification of the design of the database's unique identifiers and the behavioural conflicts that include the conditions and constraints.

2.6 Levels of Information Systems Interoperability (LISI)

The levels of interoperability of individual systems need to be evaluated to determine the stage at which the systems can interact with each other. When it comes to interoperability between heterogeneous systems, there is a need to describe the differences and identifying gaps that are preventing the systems from being rated at a high level of interoperability. This can only be achieved through LISI (Knight et al., 2020).

According to Cestari et al. (2018), the LISI is a maturity model that assesses and quantifies the systems' capability to exchange and use data. This model consists of five evolving stages that determine the complexity of interoperability among different information systems. According to this model, "*each higher stage signifies an increase in interoperability capabilities over the previous level of system-to-system interoperability*" (Cestari et al., 2018).

As documented by Knight et al. (2020), Cestari et al. (2018), and Khennou et al. (2017), the levels for information systems interoperability are as follows:

(a) L0: Isolated interoperability in a manual environment

This level consists of stand-alone and fragmented systems with no direct electronic connection and can only support manual data integration through telephones, fax, or where data can only be merged through traditional import/export processes

(b) L1: Connected interoperability in a peer-to-peer environment

On this level, a physical connection is available to support basic direct interaction between distinct systems. However, only homogeneous data can be exchanged via a local area network. There is also a limited data merging capability.

(c) L2: Functional interoperability in a distributed environment

On this level, heterogeneous systems exchange data via a local area network. Logical models are also available and can be shared. Furthermore, there is a provision for web-based data.

(d) L3: Domain-based Interoperability in an integrated environment

Independent systems are integrated via a wide area network and the information is shared through domain-based data models that allow multiple users to have access to the data. It also supports group collaboration and data merging from multiple sources. It also supports daily database transactions that are facilitated by business logic.

e) L4: Enterprise-based interoperability in a universal environment

This level of interoperability includes enterprise models and procedures that support sharing data seamlessly among multiple domains via a universal environment. This allows data to be accessed by different users at the same time and it also supports advanced collaboration as well as the merging of heterogeneous data.

2.7 Challenges Associated with HIS Interoperability

In a perfect world of systems development, information systems are designed according to a well-defined requirement specification. These requirement specifications are mainly based on related data structures and common interface designs that support a well-defined flow of information. Thus, interoperability between systems with similar architectural designs is mostly achievable (American Hospital Association, 2019). However, the issue of data sharing between heterogeneous systems remains a challenge in healthcare due to the level of differences in data collection tools, semantics, syntactic, sensitivity, and availability of patient data (Bisama et al., 2019). Therefore, in this section, numerous issues associated with heterogeneous systems integration are reviewed.

a) Systems compatibility issues

Systems interoperability is much more than the technology itself. Interoperability is a socio-technical issue. Socio-technical issues include the function of operational concepts and scenarios, policies, processes, and standards (IAMOT Conference, 2018). These attributes define the system model. A system model defines the architectural design or the blueprint which represents how the system is modelled (Faustmann et al., 2019). Therefore, a system model is a crucial element to consider during systems interoperability. However, when interoperability involves legacy systems, it becomes more complex as existing systems lack similarities in terms of designs and implementations (Measure Evaluation , 2018).

Similarly, according to Nafissi et al. (2018), the fundamental problem that is raised by semantic heterogeneity is the fact that data duplicated across multiple databases is represented differently in underlying database schemas. Additionally, Nafissi et al., (2018) highlight that the challenges in the interoperability of different systems are mainly caused by the same or overlapping data that is captured and stored in different databases. Thus, interoperability is increasingly becoming complicated as time passes as it focusses on how information and knowledge through the flow of activities of business operations can be used to enhance data sharing among systems (Vergeti et al., 2018) Similarly, Aggoune et al. (2018) indicate that the breadth of developing technologies is an ideal option to resolving some operational issues in the organisation, however, it complicates the interoperability of the e-health information system which is already associated with a lot of challenges in terms of standards and diverse data semantics.

b) Standards

Generally, standards are agreed upon specifications that control and support distributed systems to work together (Abdellah et al. (2018, 2018). Abdellah et al. (2018) also define standards as common grounds that standardise systems to be compatible in terms of user interfaces, data presentation, and system protocols. Most of the legacy systems in healthcare are not implemented according to universal standards, either because the universal standards were not introduced by the time of system development or because most of the systems were designed for a specific purpose to support individual projects or to protect companies' market share which in most cases have limited or no interoperability capabilities (Hamunyela & Dlodlo, 2017). On the other hand, most clinical processes that are intended to be universal are also not standardised as they are mainly generalised or subjected to local practices and the availability of resources in health institutions. This has resulted in confusion and complications during the implementation of heterogeneous systems interoperability (Mergel et al., 2019).

c) Organisational challenges

The field of eHealth has become increasingly crucial in the past years. However, the health field is faced with challenges because it involves different stakeholders with different interests, and according to IAMOT Conference (2018), interoperability is not purely technical but it involves solving socio-technical issues. This includes the collaboration of different stakeholders to ensure that the processes are clearly understood which can be done through the negotiation of business processes to develop a better understanding of different processes which may be in different organisations and is managed by people with different process understandings (Stouten and Rousseau, 2018).

d) Security concerns

The rise in adopting interoperability in eHealth has made a significant improvement in providing quality healthcare to patients. However, it has also created an increase in potential security concerns (Snell, 2018). Thus, data security in healthcare is regarded as a key issue. Generally, patient data is sensitive and needs to be handled with the utmost confidentiality, therefore, it is essential to create a balance to keep the patients' data private and secure while ensuring that authorised users have access to the data they need (Davis, 2019).

e) Lack of patient identification

Patient identification is a major challenge when it comes to matching the correct record of each patient to be exchanged across systems. Legacy systems are mostly associated with a different way of patient identifications. Furthermore, these patient identifiers are not always as unique as more than one patient can be assigned the same unique ART numbers. Therefore, there is a need to develop a standardised method to uniquely identify patients. Matching individual records accurately to their medical record is crucial in avoiding errors that might result in patient harm (Riplinger, Jimenez & Dooling, 2020).

2.8 HIS Interoperability and Standards

To achieve interoperability in healthcare, especially when heterogeneous systems are involved, there is a need to make provisions for common grounds for the systems that will form part of the data sharing process. These common grounds should include the system's compatibility in terms of platforms, data semantics, and architectural designs (Kate, 2018). Therefore, there is a need to establish commonness in e-health which can be accomplished through the development of standards. Standards are associated with various descriptions. Kubben et al. (2019) define standards as agreed upon guidelines that specify the uniformity of products or artefacts in terms of their features, conditions, or methods. Similarly, Abdelkafi et al. (2019) indicate that standards stipulate requirements and specifications defined by selected stakeholders on which a determined product should be developed based on. While Kate (2018) defines standards as agreed-upon ways of integrating systems. Standards are categorised into two broad categories namely, proprietary and open (Taylor, 2017). Proprietary standards are developed by profit-making organisations and they are subjected to copyright laws, while open standards can be maintained by both profit and non-profit making organisations and can be used for free or at a nominal fee by the public (Burson, 2018). These two categories are further broken down into numerous categories by different researchers according to their local needs of standards at regional or national levels. This includes the European Commission that categorises standards into four groups namely, official, voluntary, industry, and open, and further classifies standards into the following groups, formal, informal, and private respectively (Abdelkafi et al., 2018).

In this section, several organisations that are involved in the development of e-health interoperability standards are reviewed. However, this review only includes the standards that are mainly focusing on data sharing aspects.

a) World Health Organisation: This organisation works in partnership with health data standards such as the international health terminology standards development organisation (IHTSDO) currently known as SNOMED, HL7, and LOINC, to develop standards responsible for facilitating the semantic and cross-mapping of clinical terminologies (Awaysheh et al., 2018).

b) Health Level 7 (HL7): This is a non-profit American National Standards Institute (ANSI). This organisation is accredited for the development of data exchange standards between heterogeneous systems and its benefits follow the type of members signed up for (Jaybal, et al., 2018).

c) Integrating the Healthcare Enterprise (IHE): This organisation in collaboration with health care professionals and stakeholders, aims at improving the way of data sharing across different but related systems by defining the health care processes and establishing standards based on the required standards specifications to facilitate communication (IHE, 2018).

To successfully achieve a complete interoperable environment between heterogeneous systems on both semantic and syntactic levels of interoperability, it is essential to implement interoperability according to various standards categories that facilitate data exchange in e-health. Although the standards categories are crucial for interoperability, different researchers stick to different standard categories due to the lack of consensus on the best standards categories to use to achieve interoperability among disjointed health systems (Kate, 2018). Thus, in this section, several standards categories that support the interoperability of heterogeneous systems are reviewed according to Kubben et al. (2019).

a) Interoperability frameworks and architecture: Standards in this category are used for the establishment of enterprise architecture of health systems to ensure that the design of the system is developed in a way that enables them to support data sharing within and beyond organisational boundaries.
b) Identified standards: In this category, the standards are responsible for uniquely identifying different entities according to their participation in the interoperability of the systems. This includes the patients, healthcare professionals, hospitals, laboratories, and other related health institution IDs.
c) Messaging/information exchange: This category of information exchange is supported by IHE standards organisations that develop infrastructure that facilitates data sharing between different systems. On the other hand, this category is also supported by the HL7 organisation which is responsible for defining the context and format of the data to be exchanged. Furthermore, these standards also ensure that the data is exchanged safely.
d) Clinical terminologies and Coding standards**:** Here the standards ensure that the same field names and terminologies used to represent medical conditions, symptoms, and diagnosis in different systems are standardised to avoid ambiguity and conflicting meanings. This process is supported by the LOINC standards organisation.
e) System functional standards: These standards facilitate the infrastructure settings according to the level of the health care institution, for example at the clinic, in-patient, or out-patient departments.

f) Security and Access Control: These standards maintain the access control data being transmitted by ensuring that security measures are implemented to control who has access to the data and at what level.

Standards remain the key drivers in achieving systems interoperability (Angula, 2018). However, it has been a tedious job to achieve interoperability between health systems, especially in developing countries like Namibia. This is because the legacy systems that are currently in use are implemented with the sole intention of supporting donor-funded projects such as HIV/AIDS and TB (Dlodlo &Hamunyela, 2017).

Therefore, the following challenges are confirmed as hindering the successful implementation of HIS standards in Africa according to Kapepo and Yashik (2018), and Furusa and Coleman (2018).

a) Lack of enough funds for the African countries to be part of the standards development committees as the cost of their membership is very high
b) Lack of the level of experts required for the development of interoperability standards
c) Lack of understanding of the importance of standards in achieving interoperability
d) Standards that are implemented are not per the universal interoperability standards, and as a result, these standards that are developed locally are competing, contradicting, or overlapping with each other.
e) Different health information systems are implemented using different standards.

2.9 Functional Data in HIS

One of the most important elements of healthcare management is data. Data is unprocessed raw facts or statistics gathered and kept as a reference to validate activities, processes, or services performed or offered (Kubben et al., 2018). In healthcare, there is a well-known statement for data collection that says: “if it’s not documented, it was not done” (Russell, 2019). This phrase is used to emphasise how crucial data collection is in saving the time and life of the patient throughout their treatment journey (Russell, 2019). The healthcare system consists of massive, complex, and diversity of data which is referred to as the ‘Big data’ era in the healthcare sector (Kubben et al., 2019). Big data is defined as a set of large volumes of heterogeneous data generated from processes and interactions (El-aboudi & Benhlima, 2018). Similarly, Palanisamy and Thirunavukarasu (2017) describe big data using four defining characteristics as a large amount of data (Volume) generated at a certain speed (Velocity) in different formats (Variety) from reliable sources (Veracity) (Kumar & Singh, 2018). However, Wang (2017) opposed the veracity of big data due to the high inconsistency of data generated from diverse sources, thus concluding that big data is ambiguous and untrustworthy.

2.9.1 Data Heterogeneity

One of the huge challenges associated with big data is its heterogeneity (El-aboudi & Benhlima, 2018). This means that the data has different data types and formats which are mainly collected from various data sources. According to Wang (2017), this data is likely to be incomplete, redundant and as a result, the data quality is low.

The different types of data heterogeneity (Wang, 2017) are:

a) Syntactic heterogeneous: When data from different systems is not represented in the same language;
b) Conceptual heterogeneity: This is when the data semantics are different or when there is a discrepancy in logic;
c) Terminology heterogeneity: This is when the data fields/ naming conversion of the same entities is different in various data sources; and
d) Semiotic heterogeneous: This is when there is a difference in the way the same entities are interpreted by different people.

Heterogeneous data are hard to integrate and difficult to analyse, and due to its poor quality, it will have a bad effect on the decisions about patients' treatment and continuity to care. Therefore, to eliminate the differences in data collected from different points of healthcare, the data needs to be cleaned (Wang, 2018). Similarly, Spotless Data (2018) highlighted that due to the method through which health data is collected from various points of care, it is expected that the data is full of faults and inconsistencies. Thus, data cleaning is the way forward in improving the patient's data quality. Data cleaning involves the ability to recognise missing data from the patient records. The missing data is captured on the system from the patient's physical file. Furthermore, incorrect data is replaced with the correct data items, and the data that lack sense needs to be deleted from the data source. Moreover, the data should also be duplicated in order to improve the quality of data. Once the data is clean and the quality is improved, there is a need for it to be integrated.

2.10 Data Integration

Data integration is a process of merging data from different sources. This data is presented in various types and formats (Hughes, 2018). Data integration is crucial in providing quality healthcare to the patient (Limaye, 2020). This is because data integration assists in providing a complete picture of the patient's treatment history, by ensuring that all different data from various data sources are combined into one summary (Limaye, 2020). To achieve data integration for HIS, there is a need to determine data fields from different data sources that need to be integrated. In most cases, this will include fields that are required to generate a complete summary of a patient's treatments, important fields required for analytics, or fields necessary for reporting needs (Limaye, 2020). Once the fields are determined, the methods to be used to integrate the identified fields from different systems need to be highlighted. According to Levin (2019), one of the best practices of a heterogeneous data integration study is to select a data model that will suit your data integration needs. The data model includes creating a data schema that mainly focuses on achieving data integration through field mapping. Furthermore, HL7 and open EHR can also be used to achieve data exchange between heterogeneous systems (Levin, 2019). Similarly, given the diversity of medical data, it is crucial to identify key health processes that contain key data fields and concepts that are required for data exchange in HIS (Levin, 2019). This will help the researcher to determine relationships or dependencies among the selected key processes and concepts. When the HIS processes, fields, and concepts are selected to be included in the HIS interoperability processes, it is crucial to understand what the integration processes are aimed to achieve. This assists with the inclusion of all the required fields without leaving out any data field required in achieving the overall goal of the research. Furthermore, one of the baseline requirements for developing a conceptual data model is that once the key functions are selected, the conceptual entities should also be determined (Awaysheh et al., 2019). Conceptual entities of a data model should be selected according to the important roles they represent in the systems. The entities selected will be used in creating the conceptual model metadata (Schallehn, 2019). Metadata helps to determine similar concepts (homonyms/synonyms) and this includes common data field used, processes, and terminologies that mean the same thing but are named differently (Villanova, 2019). Besides, meta-data is important to be used in a data model because it enables the data model to handle future changes by controlling scalability and the flexibility of the system to enable evolution when needed.

2.11 Design Science Research Theory

A design research theory is a methodology that is used in information systems research as a framework that stipulates step by step guidance on how an IT artefact can be designed in a more effective and practical manner (Van der Merwe et al., 2019). The design science theory provides seven guidelines that can be used as reference in solving real life IS challenges (Hevner et al., 2004) as presented by Brendel et al. (2018). The seven guidelines include design as an artefact, problem relevance, design evaluation, research contribution, research rigour, research as a process and the communication of the research (Brendel et al., 2018).

2.12 Interoperability Interventions in the Healthcare Sector: African Context

Interoperability of HIS is a huge deal, especially in developing countries that are working with siloed, disjointed, and heterogeneous HIS (Mudaly, 2018). The lack of integration in HIS poses a major threat to the system's usefulness (Kesse-Tachi et al., 2019). Thus, most of the ministries of health (MoH) in countries dealing with distributed legacy health information systems are working tirelessly towards achieving a better HIS.

In this section, the researcher highlighted interoperability progress in health information systems in Africa. The MoH of Rwanda in collaboration with its partners and donors is leading a project called Rwandan Health Enterprise Architecture (RHEA) that is responsible for implementing the RNHIS. The implementation of the RNHIS is planned to be carried out in phases. In the first phase, the RMOH and its implementing partners developed a foundational service by developing several applications as registries that are responsible for storing and exchanging information for different cadres in their NHIS. In this phase, the project also managed to integrate two maternal systems used in 13 health centres in Rwanda. In order to achieve interoperability between the two maternal systems and the registries, the RHEA project implemented a Health Information Exchange (HIE) to facilitate interoperability. HIE is a method of electronically exchanging health care data across different health institutions (Mello at el.,2018). The HIE is an interoperability layer that is used to facilitate the data exchange between two maternal health information systems in 13 health centres and the registries. This interoperability layer will also be used to manage the scalability of the RNHIS to cope with the growing interoperability infrastructure (Mello at el.,2018).

The approach used by the Rwandan NHIS project is proven to be working for its planned health information system infrastructure. However, the RHEA project is a huge project being carried out by the RMOH in collaboration with 14 dedicated partners with seven different development teams making minimal adjustments to the legacy systems to fit them in the NHIS structure. Thus, the objective of this research is to design a model that can enable interoperability between EPMS and EDT systems.

Apart from the good practice carried out in the RHEA project, the researcher has also identified gaps in the approach. In the RHEA project, the study did not mention how the NHEA structure manages to resolve issues related to syntactic and semantic processes, programmatic heterogeneity, or socio-technical issues, which is a huge deal towards achieving the goals of this study. The study also failed to specify the types of standards that the RHEA used to support the implementation of the HIE architecture. Furthermore, the study did not indicate the type of HIE architecture they adopted.

Similarly, the South African Health sector consists of numerous incompatible health information systems (Katurura & Cillies, 2018). In the years towards 2000, the MoH in South Africa planned to develop a system to integrate data among both public and private health institutions known as the National Electronic Health Record (Ch Katurura & Cillies, 2018, 2018). However, after properly examining all the essential requirements needed to achieve data integration at all levels, the project was put on hold until the finalisation of the National eHealth Strategy in 2012. According to the National eHealth Strategy report (2019), the National Department of Health (NDoH) in South Africa has indicated that the division has made evident interoperability interventions towards achieving the provision of quality healthcare to all South Africans. This is because the Health Information System Assessment conducted in 2015 indicated that several systems have been developed as the first steppingstones towards a digital health system (NDHS, 2019). However, the country is still battling the following challenges: Lack of enough budget, inadequate ICT infrastructure, challenges with cybersecurity, and insufficient skilled human resources. The eHealth Strategy is intended to address challenges reported by the NSDA (2010-2014), in which the report indicated that irrespective of the huge monetary investments made in procuring health information systems, the health system is still failing to provide satisfactory support to the health business processes and it is incapable of delivering adequate data required for the monitoring.. Therefore, to deal with the challenges as articulated in the National Health Strategy (2020), the NDoH of South Africa developed a National Health Normative Standards Framework (HNSF) (Chowles, 2018). According to the NDoH of SA, the HNSF (2014) report mentioned that the implementation of the national eHealth Strategy produced local benefits to some extent, however, it is yet to create a desirable "network effect" due to the lack of interoperability among heterogeneous HIS (NDHS report, 2019). The HNSF is a set of detailed guidelines that are put in place to support the process of systems interoperability in healthcare and to facilitate the development and implementation of standards to facilitate data and information dissemination across HIS at all levels in both public and private health institutions. The HNSF will mainly be focused on establishing the baseline layer to make interoperability provision towards accomplishing a fully functional Health Enterprise Architecture, as the HNSF will be the component that will contribute to the development of the Health Enterprise Architecture (HEA) (Chowles, 2018). HEA refers to detailed guidelines on how the data and technology can be used to facilitate healthcare operations. Furthermore, the implementation of HNSF is visualised as a future solution in addressing interoperability issues by providing guidelines to system developers to design and implement a health system following the setup and agreed-upon standards, and integration profiles for data in public HIS. Therefore, the HNSF will mainly focus on dealing will semantic, syntactic, and organisational interoperability on systems that administer patient-level data and manages the National Indicator Data Set (NIDS) (NDHS Report, 2019).

On the other hand, Uganda, Ghana, and Zimbabwe are also working hard towards HIS interoperability. Uganda has conducted an interoperability readiness evaluation for the health information systems (Measure Evaluation, 2019). This was done in the form of a workshop where the Ugandan MoH and its stakeholders combined to measure the HIS interoperability maturity level. The result of the evaluation indicated that among other many challenges such as fragmented data sources, inadequate ICT infrastructure, and monitory aspects, the HIS governance is found to be the main barrier when it comes to HIS interoperability. Ghana healthcare is supported by several systems that generate high-volume data that is stored in silos (Kesse-Tachi et al., 2019). According to Kesse-Tachi et al. (2019), the adoption of eHealth has not been forthcoming as compared to integration in other sectors. This is because most hospitals' HIS are either manual or partially electronic. However, the MoH in Ghana is currently working on an eHealth strategy that was launched in 2010. Similarly, the Zimbabwean MoH is also aware of the benefits of eHealth in healthcare. However, eHealth implementation is hindered by several challenges and these include poor ICT infrastructure, security concerns, and financial reasons (Furusa & Coleman, 2018).

2. 11 Chapter Conclusion

General concepts on information systems and HIS integration and interoperability reviewed by the researcher are documented in this chapter. Challenges associated with HIS interoperability and interoperability interventions in healthcare, particularly the African context were also reviewed. The researcher further reviewed and studied topics that provided insights and understanding of the research objectives and provided a knowledge base on how the research questions can be answered.

Chapter 3: Research Methodology

3.1 Introduction

A research methodology is an approach of how a researcher intends to go about the work by describing and explaining how the procedures were carried out during data collection, data analysis, and how the conclusion was reached (Abutabenjeh & Jaradat, 2018). The research methodology chapter discussed the processes used in the research to explore the research problem and find answers to research questions. The several methods and theories were reviewed that made it possible for the development of the research design. The main method used in this research is the design science that was applied to design the interoperability model. The data collection process was divided into two parts. The first part constitutes the document analysis method whereby EPMS and EDT user manuals and data dictionaries were studied to determine the data integration requirements for the development of the data exchange model for the EPMS and EDT systems. The second part of the data collection process was completed by conducting semi-structured interviews with the relevant departments of the MoHSS.

In this section, the research design and methods selected for the research are explained and justified. Furthermore, reference to the benefits and constraints for the methods and techniques selected to be used in achieving and answering the research questions are covered. This chapter is organised as follows: firstly, the research design that articulates how the research objectives were achieved and secondly, the research approach, data collection, and data analysis methods.

3.2 Research Design

The research design refers to the overall approach that the research intends to be implemented to obtain answers to the research questions. The research design further lays out the blueprint of how the research data is collected, measured, and analysed (Boru, 2018). The research design also indicates the type of data required for the research. The methods that were used to collect and analyse data are described in this section. The research design further stipulates how the approach ensured that the research problem is tackled in terms of data collection and data analysis. This section further includes the benefits and constraints to justify the selection of the methods and techniques that were used in achieving the research objectives. The aim of this research was to design a model that would enable interoperability between EPMS and EDT systems in their current states.

This research followed a qualitative research methodology as the research methodology approach to use in collecting data from DSP staff and the HIS department of the MoHSS. The methodology enabled the research to explore, investigate, and to have a closer examination of a specific case, which in this research is the EPMS and EDT systems that are recommended to interoperate. The interrogation of the subject matter through research objects was achieved through explanations provided and reading of the existing documents. The methodology allowed the researcher to have an in-depth understanding of the system's processes and to draw a conclusion based on the real-life situation of EPMS and EDT systems. The researcher took the liberty of selecting the qualitative research approach which allowed the use of a wide range of data collection methods such as conducting interviews, questionnaires, group discussions, and observation. For this purpose, semi-structured interviews were a suitable data collection technique. This research approach further gave the research great flexibility to be open and pay attention to new details or opinions that might come up during the process of investigation. Thus, this approach was selected over the other methods because it allowed the research to engage directly with the staff of DSP which enabled the researcher to collect data on common processes of both EPMS and EDT systems. The researcher was able to pick up how the contributors think the solution can be of great help to their current problem. The contributions were incorporated as inputs in the proposed solution. On the subject matter, conducting semi-structured interviews assisted the researcher to gather information on the overall IT infrastructure, available HIS standards that can be used to support the data exchange models suitable for the proposed interoperability model, and the security concerns associated with data sharing. To sum it up, the research used the data collection methods that are suitable to determine models and standards that can support interoperability between EPMS and EDT systems.

On the other hand, due to the flexibility of the qualitative data collection methods, Fernandez (2018) outlines that the findings of interviews are influenced by the opinions and judgments of the interview participants which result in biased findings. However, during the data collection of this research through semi-structured interviews, the researcher can attest that the data collected provided reliable key inputs which were picked up in most of the interviews that were conducted.

3.4 Data Integration

The research adopted a data integration approach that enabled the integration of common data that is represented in different data models and semantics of EPMS and EDT systems. In the EPMS and EDT data integration section, the research defined and described the data integration processes of how EPMS and EDT systems data can be integrated.

The role of the data integration framework is to provide guidance on how to combine data and share data from heterogeneous systems by providing several steps that lead to data integration and eventually the sharing of the data. Data integration helped the researcher to have the knowledge and understanding of how functional data and the data's heterogeneity can be resolved to achieve data integration for EPMS and EDT systems.

3.5 Design Science Research Approach

Design science research approach is a framework that provides seven guidelines that are used as a knowledge base and guideline to help the study to understand specific design problems/challenges in the field of information systems, and it is a way of providing guidelines to come up with a suitable solution in the form of an artefact (Venable et al., 2017). Venable et al. (2017) describe IT artefacts as follows:

a) As a method or instantiation

b) An artefact is a construct, a model/framework that can be useful in the development and use of information systems

c) It can also be described as a way to represent components of an organisation and its stakeholders, that are particularly involved in using computer-based artefacts. The seven guidelines were simply adopted to guide the designing of the model.

The table below describes the seven guidelines of the design science research in IS research according to Hevner et al. (2004, as presented by Brendel et al., 2018; Hazbi; 2018).

Table 3.5.1: Design Science Research Theory Guidelines

Design science research guideline	**Definition**	**Relation to this research**
Guideline 1: Design as an artefact	This guideline should formulate an innovative and purposeful artefact in the form of a construct, model, method, or instantiation	This research designed an innovative solution in the form of a model that provides guidelines to achieve EPMS and EDT systems interoperability
Guideline 2: Problem relevance	The overall aim of the design science research theory is to provide a technology-based solution to a known and targeted business problem	The EPMS and EDT interoperability model aims to address interoperability challenges such as incomplete data, discrepancies of common reports, and unreliable data for decision making
Guideline 3: Design evaluation	The business environment mainly determines the requirements on which the artefact value in terms of quality and utility is based on. This includes the infrastructure in which the artefact depends on to operate effectively. This guideline also	A qualitative data collection approach is adopted. This includes document analysis of technical documents of both EPMS and EDT systems to determine their requirements in terms of

	includes the definition of metrics and the collection of data	architecture and processes. Furthermore, semi-structured interviews were conducted to collect key inputs in terms of available technology and overall support on EPMS and EDT system integration
Guideline 4: Research contributions	The artefact developed should be a solution to a specified problem. It should be an interesting contribution to the knowledge base in terms of a clear guideline, model, construct, or instantiation	The EPMS and EDT system interoperability model has first and foremost provided a technology-driven solution to the MoHSS. This model contributes to the knowledge base on IS research in general
Guideline 5: Research rigor	Research rigor mainly focusses on the research approach. This guideline evaluates the effective use of the knowledge base and exposing the researcher's skills and the ability to provide relevant methods to develop the artefact. This includes the data collection methods and how the collected data is analysed	The researcher used the knowledge obtained through reviewing articles and studies focusing on IS interoperability. The knowledge obtained was applied in both data collection and analysis and provided reliable input to the development of the

		EPMS and EDT systems interoperability model
Guideline 6: Design as a search process	The ability to search for the most suitable solution to the targeted problem while still adhering to the required laws and regulations or ethical considerations. This also includes utilising available resources	The researcher found the development of the EPMS and EDT interoperability model as a suitable solution to the problem defined in chapter one of this research. The researcher recommended the use of open-source software in data extraction and loading that will not put too much financial restrictions on the MoHSS as most interview participants indicated that lack of resources constrains the MoHSS from supporting HIS initiatives. Furthermore, the interoperability model did not violate any of the MoHSS HIS standards that are in place
Guideline 7: Communication of the research	The artefact must be presented to the relevant audience. This includes both technical people that ensure that the artefact produced is	The EPMS and EDT systems interoperability model was presented to all relevant departments of the MoHSS.

	implemented and the beneficiary to the solution. The artefact will also be used as a knowledge base to contribute to the future evolution of information systems	Furthermore, if granted permission from the MoHSS, the researcher will publish the EPMS and EDT systems model to contribute to the IS industry knowledge base which will be used as literature by future researchers.

The role of the Design Science Research approach was to provide the research with a framework to follow in producing the data exchange model. The design science research approach helped the researcher to gain an understanding about the creation of an innovative solution to a specifically targeted problem in the form of a model. Firstly, the Design Science research methodology (DSR) provided guidelines to the researcher on how to design and develop a reliable technology-based solution to a specific problem in the form of a model. Furthermore, the DSR helped the researcher to present the EPMS and EDT systems interoperability model as an innovative solution that can address DSP data sharing challenges. Moreover, this interoperability model is a contribution to the IS research industry knowledge base and a guide to the ministry on how different information systems can be integrated to better the data collection processes.

3.6 Design and Creation of the Research Approach

The design and creation approach is crucial to information systems. This research approach involves the application of innovative ideas to solve problems in a more efficient and effective way by applying information technology to build artefacts, processes or interventions while contributing to the knowledge base (Venable et al., 2017). Design and creation research consist of five phases (Deng et al., 2017).

Table 3.5.2 Design and Creation

Research Phase	**Description**
The conceptual phase	This phase is mainly concerned with understanding and familiarising yourself with the research problem by reviewing the literature and defining the scope and purpose of the research
The construction of research design phase	This phase involves drawing a plan for your research. This includes selecting the research design, outlining the research procedures, theories, data collection methods, and sampling
Empirical phase	This includes the implementation of all the data collection plans and the preparation for the data analysis process
The analytical phase	This phase involves carrying out the data analysis and interpretation procedures
Disseminative phase	The process of communicating the research's findings and giving research feedback to the relevant audience

3.7 Data Collection Methods

This research adopted a qualitative research methodology as a data collection approach. This strategy is a form of social action that allows the researcher to do the data collection themselves, by conducting interviews, analysing documentation, or observing situations to collect data (Mohajan, 2018). Furthermore, the qualitative data collection method is a descriptive form of data collection that allows the researcher to develop a technique on how to collect inputs “as-is” using different data collection methods while avoiding the researcher personal feeling, thoughts, and perceptions as much as possible (Jovancic, 2019).

3.7.1 Interviews

Generally, an interview is an official way of meeting one or a group of people to have a conversation whereby the questions are asked and answers given. Interviews are a form of the qualitative research method of collecting data from a targeted person(s), whereby the interviewer(s) asks questions and the interviewee(s) provides clarity to those questions. The research selects the suitable type of interview that provides answers to the research question according to the research design (Ainsworth, 2020).

3.7.1.1 Semi Structured Interviews

This is one of the qualitative data collection methods that is performed by conducting interviews according to the interview protocol guide to support the research throughout the interview process. This method was found suitable for collecting data for this research because it allowed the researcher to engage in conversational topics related to the research with the selected participants of DSP and MoHSS’s IT departments. This provided flexibility to the researcher to ask for additional information about EPMS and EDT.

Therefore, this research method was used to guide the data collection by conducting semi-structured interviews with the DSP staff and the MoHSS’s IT department. The strategy further enabled the research to perform comparisons to check if the data collected fits the theory. This method allowed the researcher to obtain first-hand information from the DSP and MoHSS staff which is more reliable in obtaining the intended results.

3.7.2 Document Analysis

The research used texts and documentation about EPMS and EDT systems. The documentation reviewed includes available technical documents, user manuals, and data dictionaries. The documents were selected for data collection because they contain information that is related to systems platforms, database structures, systems processes, and data.

3.7.3 Participants Selection

For the research to be successful, the sampling of the research population is very important (Etikan & Bala, 2017). In research there are two main types of research sampling, and this mainly depends on the type of research design and the data collection methods (Etikan & Bala, 2017). According to Etikan and Bala (2017), there are two types of research sampling techniques namely:

a) **Probability sampling**

   This is when every object of the sampling population has an equal opportunity to be part of the research.

b) **Non-probability sampling**

   This method does not depend on random selection techniques but it works with a selected sample size of the sampling population.

This research adopted a judgmental sampling which is also known as a purposive sampling method. This sampling method is part of the non-probability research sampling method. This technique only includes a targeted sample size depending on the researcher's judgment. Thus, this technique was found suitable for the research as the research is only interested in specific DSP and MoHSS's IT departments' staff that deal directly with the administration of EPMS and EDT systems. The first interview was conducted with 1 systems analyst and 1 data manager from DSP. Two M&E officers from DSP, a system administrator, 1 pharmacist from the pharmaceutical department and 2 MoHSS's IT administrators from the HIS department. These participants were asked to answer process-related questions and to report on the challenges for both EPMS and EDT systems. The participants were given a chance to express their feelings on the importance of EPMS and EDT systems and how the integration of the two systems can benefit the ART programme. The participants were allowed to openly discuss any other issues related to EPMS and EDT. Similarly, a total number of 2 IT experts from the MoHSS's IT department were interviewed on questions related to IT infrastructure, IT governance, standards, and security issues. This interview process followed the same format as described for the DSP staff.

3.9 Data Analysis

To generate themes that are a contribution to the design and development of the EPMS and EDT systems' interoperability model, three research cycles of the design science research framework based on Hevner et al. (2004 & 2007, as cited by Brendel et al., 2018) were adopted. The three research cycles consist of the relevance cycle, design cycle, and rigor cycle that were used as a baseline that guided the analysis of data collected through document analysis and semi-structured interviews. The research adopted two main data analysis approaches, namely, thematic and content data analysis approaches. The data collected through document analysis was analysed using a content analysis approach. The research adopted one of the content analysis method which is conceptual content analysis whereby four steps of data analysis are applied. These include content sampling, units' definition, and categorisation, coding rules development and application, and finally results in analysis and conclusions. Data collected through semi-structured interviews were analysed using the thematic data analysis approach.

The researcher generated three main themes from the data collected through semi-structured interviews. The first theme generated is the requirement theme. This theme consists of data alluding to the real problem at hand as identified by the participants. The requirement theme was repeatedly picked up in every interview conducted. The second theme generated by the researcher from the semi-structured interviews is the environment. The environment theme consists of things that can influence the development of the interoperability model. This theme is further broken down into smaller themes and these include political interest, technology, and infrastructure. The combination of different themes that form part of the environment theme was also repeatedly picked up from all five interviews that were conducted. The last theme was generated according to the collected data in the proposed solution which consists of the proposed interoperability ideas from the participants which were further combined with the knowledge base on data integration framework and designed science research that the researcher incorporated in the development of the EPMS and EDT interoperability model.

3.10 Data Triangulation

The findings obtained from both content analysis and thematic analysis were combined whereby the research compared the findings to cross verify the findings and to identify findings that were only obtained by one data analysis method (Vogl et al., 2019).

3.11 Research Ethical Considerations

In general, ethics is the rule that differentiates what is morally right from what is morally wrong and vice-versa (Resnik, 2020). In this research, ethics is used as a guidance tool to provide standards of conduct and moral codes followed by all the researchers throughout their research processes (Adhikari, 2020). Furthermore, the research norms encourage knowledge and truth gathering which are the aims of the research. Research ethics further discourages falsifying, misrepresentation, and plagiarism along with many others (Adhikari, 2020). This research adhered to all the research ethics and code of conduct as required by NUST and the MoHSS.

NUST requires all the postgraduate students to identify a research problem and formulate a research topic from it. The researcher submitted a research proposal within six (6) months. The researcher had been in close communication with the research supervisor and had also submitted the work in progress reports as required by the research department. Also, the researcher submitted and presented the research proposal at faculty level, where different faculty members provided their views and opinions on the research proposal and the comments guided the researcher. Finally, the researcher submitted a concept paper to the postgraduate committee which also granted permission for the research to continue with data collection and the thesis write up.

Before the data collection process was done, the researcher consulted the MoHSS's Research Department which is responsible for approving all the data collection in the MoHSS. The MoHSS's Research Department requested the following documents from the researcher: a complete research proposal document, the researcher's CV, ethical clearance from NUST's ethical clearance committee, ethical and consent forms, and the data collection tools. The approval of the research took 4 weeks and the researcher was granted permission for starting with data collection through a data collection approval letter that was to be submitted to all the departments involved in the data collection. This includes DSP, HIS department, and Pharmaceutical department.

3.12 Chapter Conclusions

A qualitative research approach was used to collect data through document analysis and semi-structured interviews. Selected contents from user manuals and data dictionaries for both EPMS and EDT were used for data collection. Eight employees from DSP, Pharmaceutical, M&E, and HIS departments of the MoHSS participated in collecting data through semi-structured interviews.

Chapter 4: Data Analysis and Findings

4.1 Introduction

This chapter presents a step by step processes content and thematic analysis approaches that were carried out to achieve the research findings grounded in the actual data collected. In this chapter, the metadata for EPMS and EDT are illustrated. Themes were generated from thematic, reviewed, redefined and renamed.

4.2 Content Analysis

Four steps of conceptual content analysis are stipulated below. Step 1: Select the content to analyse then the data to be analysed is collected from EPMS and EDT systems' user manuals and data dictionaries. Both user manuals and data dictionary books have large contents. User manuals have contents on data capturing processes, system behaviour, reports, as well as tips and notes on how to navigate throughout the systems. Data dictionaries consist of systems' platforms, syntax, semantics, terminologies, and installation instructions. Therefore, the researcher did not analyse all the texts in the user manuals and data dictionaries. The researcher used the research questions to sample the sections of user manuals and data dictionaries to be included in the data analysis. The researcher sampled the sections that have texts on the following elements:

a) EPMS and EDT data capturing processes to identify common data fields;
b) Sections on the Systems' back-end structures; and
c) Reports sections to identify and study common reports.

Step 2: Define the units and categories of analysis

For the first selected sample of data, common data inputs captured in EPMS and EDT were selected to represent the units. Based on the research questions, the common data were categorised based on functional data and compatibility issues. On functional data, the researcher focused on data types and formats of common data fields and compatibility issues associated with the heterogeneous system.

Units 1: Common data

EPMS and EDT systems have many common data fields, however, the present research only concentrated on common data fields that are required in generating common reports.

Category: Functional data in terms of data types and formats

EPMS and EDT systems store common data in different types and formats. In the EPMS system, there are no inbuilt data input controls or validation to control the data captured in a data field. For example, the system accepts numbers to be captured and stored in a data field that is supposed to capture only names or characters and vice versa. Furthermore, a common data field in both EPMS and EDT are assigned different data types and formats, for example, the patient unique ART number, which is the EPMS's main patient identifier which is captured and stored as a character in EPMS, while in EDT the same data field is captured and stored as a number.

The table below shows the metadata of common input data fields from EPMS and EDT that form part of the data package and their description.

As illustrated below, data fields captured and stored in EPMS and ET systems have different data types. The data integration method applied is the main solution that is carried out to overcome syntactic heterogeneity. Here, common data fields are mapped together to form a single integrated view that facilitates seamless data exchange without direct communication between EPMS and EDT systems. The EPMS and EDT systems data integration process that include field mapping is addressed in more detail in chapter 5.

Table 4.1: Metadata for EPMS and EDT Systems

Data Field		**Data Type**		**Field Description**
EPMS	**EDT**	**EPMS**	**EDT**	
Unique ART Number	BSAStart	text	varchar	Patient unique identification from EPMS

Given_Name	FirstName	text	varchar	Patient's first name
Last_Name	Last_Name	text	varchar	Patient's last name
DOB	DOB	datetime	datetime	Patient's date of birth
Gender	Gender	text	character	Patient's gender
At_Start_ART_CD4	CD4Count	text	Number	CD4 count at ART initiation
At_Start_ART_Weight	WeightStart	text	Number	Patient's weight at ART initiation
Still_On_ART_Code	Status	text	character	Patient's activeness with their follows up and pill pick-ups
last_Follow_Up_date	DateofNextApp	datetime	datetime	Date of next appointment
last_Visit_date	DateofVisit	date	datetime	Date of the last visit for a clinical visit or pill pick up
Physical_Address	Address	text	Varchar	Patient's address
Start_ART	TherapyStart	text	datetime	A data when a patient starts ART

Curr_Regimen_	PAMREMID	Drop down list	character	Current regimen code
Original regimen	RegimenStart	Drop down list	character	ART start regimen
Treatment_Supporter	Caregiver	text	Varchar	Caregiver name
Address_Rx_Supporter	CaregiverAddress	text	Varchar	Caregiver address
Pharmacy_Number	PAMARTID	text	Varchar	Patient’s unique identifier number from EDT

Unit 2: Compatibility issues in terms of EPMS and EDT schema.

The EPMS system is a product of Filemaker software for both the front-end and back-end structures. In database management, a table in a database is an entity with its attributes which is linked to other tables that store related data to complete a certain transaction (Neha, 2019). However, the EPMS database structure is different from the above-mentioned concept. This is because a group of unrelated data sets is stored in one table. For example, all the data captured during patient registration is saved in one table called Card_First. This table stores data ranging from patient’s demographic data, clinical data, treatment supporter, and regimen data. Data captured into the system using a different form is also stored in a different table. This means that similar data that belongs in one entity is stored in different tables. For example, the patient’s first original regimen is captured during patient registration which is stored in the Card_First table, while the patient’s current regimen which is captured at the patient’s follow-up visits is stored in the follow-up table. Furthermore, in the entire database, there is only one main identifier that is shared across all the tables which are also the patients’ main identifiers.

On the other hand, the Electronic Dispensing System (EDT) has a normalised database structure. The EDT database has a SQL back-end structure and Microsoft Access as the front-end structure. The tables in the database are well arranged and structured. There are two base tables, “a base table is the main table of the database that keeps the metadata of the database”. These base tables form electronic patient records, medicine, and regimen records. “PAM” is one of the base tables in the EDT database which stores all the patients’ identifying data including names, date of birth, status, etc. The second base table is called the STM table that stores a list of all the ARV medicines and their related attributes. Apart from the base tables, there are also some tables that are called the transaction tables which are responsible for storing data that is created or modified during certain transactions such as patient management, dispensing, stocktaking, or inventory management. There are also system tables that store parameters that guide programme execution in the system and store error logs that are encountered while using the system. Lastly, there are also lookup tables that are used in lookups or dropdown menus on the system. The EDT database has the patients’ main identifier that is referred to as “PAMSTAID” and known as the pharmacy number. Each table has its own internal system primary key which is also used in some other tables as a foreign key.

Unit 3: Common reports

According to the user manuals, EPM and EDT systems have two reports in common, which are on new patients started on ART and active patients on ART treatment.

Categories: Common reports will be categorised based on similarities and differences

“Treatment new” report in EPMS is defined as a total number of new patients that are started on ART treatment in a facility according to the MoHSS’s ART guidelines. This report corresponds with a report in EDT called “new patient started”. This refers to the total number of patients that are started on ART in a certain facility.

Similarities: Both reports only include patients started on ART in a specific facility.

Difference: EPMS patients that were started on ART from abroad or private hospitals that are not following the MoHSS’s guidelines are restarted on ART according to MoHSS’s ART guidelines.

While in EDT patients that received ART medication from abroad or private hospitals are not recorded as new patients, they are recorded as previously treated.

Active ART patients report

Known as "Treatment current" in EPMS, which is defined as patients that are up to date with their clinical follow-up visits. This report is also called "Active patients" in EDT total number of patients that are up to date with their pill pickups.

Similarities

a) Both reports include patients that are up to date with either pill pickups or clinical visits.

Differences

a) EDT active patient reports include in transit patients that are not catered for on the EPMS system. In transit patients refers to the patients that are not transferred (patients that are relocating and are receiving ART treatment at the nearest health facility for as long they can) but are patients that are receiving ART medication at a new facility because they are visiting or were transferred with work to a new location for three months only. In most cases, in-transit patients contribute to discrepancies in the total number of ART patients receiving care.
b) EDT also records patient who sent their treatment support to collect medication for them. Patients that collected their medications through treatment are recorded as active on EDT. However, in EPMS, the actual patient needs to be there for them to be recorded as active. This results in patients being active on EDT and becoming lost to follow up on EPMS.

Step 3: Develop and applying coding rules

Functional data is coded according to syntactic heterogeneity which has determined that the EPMS and EDT systems have different data models. EDT has a relational database while the EPMS database is not relational which makes the data presentation to be completely different. The compatibility issues are coded with semantic heterogeneity. EPMS and EDT systems have completely different structures in both platforms and semantics. This indicates that EPMS is a Filemaker database, while EDT is an SQL database. This points out the differences in technologies used which make the systems incompatible. Common reports are coded in terms of similarities and differences. This has made it easier to realise the differences in clinical operations that are preventing EPMS and EDT systems to generate a common report.

Step 4: Analyse the results and draw a conclusion

The results reveal that EPMS and EDT systems are incompatible at many different levels. EPMS and EDT have many common data fields that are represented in different data models. Furthermore, EPMS and EDT systems are designed with different technologies which have influenced their incompatibility in terms of structure. The common reports produced by EPMS and EDT have a similar description which indicates that the reports are looking at the same reporting indicators, however, the systems have operational differences that result in report discrepancies.

All the above-mentioned differences in both the syntactic and semantic of EPMS and EDT systems lead the researcher to conclude that EPMS and EDT systems are not compatible. This means that the system cannot share data directly without being altered to do so. Thus, the research is committed to design and develop an interoperability model that can bridge the incompatibility gap and enable data sharing through some form of interoperability model.

4.3 Semi-structured Interviews Data Analysis

The researcher adopted a thematic data analysis technique as the main data analysis approach for the data collected through semi-structured interviews. The thematic data analysis approach was found suitable to analyse data collected through conducting semi-structured interviews with DSP, HIS, pharmaceutical, and MoHSS M&E officers.

The thematic analysis allowed the researcher to identify key findings that can contribute to the development of EPMS and EDT interoperability model development. The key findings in the form of themes were identified and extracted from all the interview transcripts.

The data collected was analysed using 5 stages of thematic analysis (Caulfield, 2019)

Stage 1: Data familiarisation

During the first stage, the researcher acquainted herself with the data collected by listening to the interview audios that were recorded during the interviews repeatedly. This was done by listening to individual audios attentively and transcribing all five interview audios into notes of the exact words spoken by the interview participants. The transcriptions of all the audios are included in the appendix section.

Step 2: Coding

In this stage, the research went through every interview's transcriptions to identify the opinions, contributions, or feelings that were in line with the research's interest. Once a phrase or a sentence was found somewhat relevant to the research's interest it was highlighted with a colour that differentiates the codes created from each other. Phrases or sentences with a similar idea/opinion were highlighted with the same colour, even though they were extracted from different interview transcripts. To create a code, at this point the researcher mainly focussed on recurring answers that were provided by the same or different interview participants. The coding of all five interview scripts is included in the appendix section.

Stage 3: Generating themes

All the codes created in stage 2 were examined to convert the codes into corresponding themes. Codes that had similar patterns were regrouped into a theme. Throughout the process of generating themes, the codes that were less relevant, too broad, or that had no contribution to the overall goal of the research were abandoned. The research named the themes with a theoretical consideration of the overall research goal and the research questions that represent the data collected from the interview transcripts. Some code names were absorbed to become themes when found fitting for a theme.

Table 4.2: Generating Research Themes

Code	Themes
○ Common report ○ Limitations ○ Distrust of reports ○ Common data	Requirements
○ Distinct operations ○ Market niche ○ Lack of funds ○ E-governance ○ Platforms ○ Infrastructure	Environment
○ Proposed solution	Proposed solution

Stage 4: Reviewing themes

Here the researcher revisited the themes that were created in the previous stage. The themes adopted were measured against the data collected once more to ensure that the data is represented accurately. During the theme revision process, the researcher identified one theme which was found to be broad. Therefore, the researcher decided to split it into themes that were more direct and fitting to represent the data. The environment theme was initially chosen to represent data that has to do with elements that can influence the EPMS and EDT interoperability model directly and indirectly. The environment theme was found fitting at first. However, the researcher thought that it was too broad. Therefore, the environment theme was further broken into three themes, namely: Political interest, technology, and infrastructure. See the final table of the adopted themes below:

Table 4.3: Reviewing Research Themes

Codes	**Themes**
○ Common report ○ Limitations ○ Distrust of reports ○ Common data	Requirements
○ Distinct operations ○ Market niche ○ Lack of funds ○ E-governance	Political interest
○ Platforms	Technology
○ Infrastructure	Infrastructure
○ Proposed solution	Proposed solution

Stage 5: Defining and naming themes

The final themes adopted to represent the interview findings were named and described. In this section the researcher explained exactly what each theme means and why it is representing the data and how the theme selected would help to achieve the research's goals.

a) Requirement theme: Firstly, the requirement was adopted to become a theme because it represents data that is alluding to the current challenges that the stakeholders are experiencing. The researcher believes that you need to understand the problem in order to find a solution for it. Furthermore, the requirement theme also represents the fundamental needs as expressed by the participants in the interviews. Here, the participants indicated that the data validation or common reports are the main outcomes they are expecting from the EPMS and EDT interoperability. The requirement theme also includes the opportunities that can be used as motivation for the solution to be developed. The research used the requirement theme as a requirement for the development of the EPMS and EDT interoperability model.

b) Political interest: Political interest was adopted as a theme to represent data that has to do with sociotechnical issues. Sociotechnical issues refer to social and organisational factors that can influence the development of the system (Winby & Mohrman, 2018). This includes operational change, policies, or human behaviour (Winby & Mohrman, 2018). This theme helped the research to identify socio-technical factors that can influence the development of interoperability in both negative and positive ways.

c) Technology: Technology is adopted as a theme as it indicates the type of platforms or software that the EPMS and EDT systems is designed in. This also includes how their back-end structures are designed. This enabled the research to provide a suitable solution that best fits the available technology.

d) Infrastructure: This theme includes data that alludes to the collection of MoHSS software and hardware. This theme helped the researcher to understand the MoHSS's network infrastructure and how it can influence the development of the interoperability solution.

e) Proposed solution: The proposed solution was also adopted as a theme because the researcher considered the inputs of the participants as the stakeholders to the solution to be provided. Here the participants indicated what they think can be the best solution to their challenges. The participants' inputs contributed to the interoperability solution where the research sees fit.

Stage 6: Producing the report

The researcher compiled a write up of the thematic data analysis process. The final write-up gave reference to the research's aim and research questions. It also gave a brief explanation of how the data was collected using semi-structured interviews and how it was analysed using the 6 stages of the thematic data analysis approach. The write-up also addressed the analysis of the findings in terms of the themes that were adopted supported by extracts from the interview transcripts. Finally, the write-up provided the main outcomes and findings of the thematic data analysis.

Table 4.4: Comparing Research's Objective Against Research Questions

Objectives	**Research questions**
○ Design and develop an interoperability model that will enable EPMS and EDT systems to interoperate without redesigning their current architectural designs	○ How can EPMS ad EDT systems interoperate without compromising their current architectural designs?
○ Examine functional data and compatibility issues of EPMS and EDT systems	○ What functional data and compatibility issues need to be resolved to achieve EPMS and EDT systems interoperability?
○ Analyse reports being generated from EPMS and EDT systems and the challenges involved in producing a common and single report	○ How can the EPMS and EDT systems produce a common report?
• Determine processes required for integration of EPMS and EDT systems	○ What processes are required to integrate EPMS and EDT systems?

A qualitative research method was followed as the research design strategy. This research strategy enabled the researcher to conduct semi-structured interviews as a data collection method with DSP, HIS, and pharmaceutical and departments of the MoHSS. Voice memos were used to record audios of the interviews. The data collected through semi-structured interviews were analysed using thematic data analysis as a data analysis approach, whereby the 6 stages of thematic data analysis were applied.

The first stage is about data familiarisation where the researcher went through all the interview recordings and transcribed them individually. In the second stage, the interview transcripts were converted into codes. The researcher was mainly focusing on recurring answers that were provided by the participants. In stage three, the classification of codes that have similar patterns into themes was done, then the themes were revised in stage four, where the broader themes were split into more direct and fitting themes. In stage 5, the themes were named and described, whereby the researcher defined the meaning of all the themes and how they related to the overall goal of the research. In stage 6, a report on the thematic data analysis process was compiled.

The first theme was generated from the data collected in the requirements, and this theme came up almost in every interview, and the researcher considered it as the backbone of interoperability solution development. The requirements theme consists of factors that the researcher took as the direction of functional requirements of the research. The requirement theme includes challenges experienced by the participants that provided a better understanding of the "as is" situation of the EPMS and EDT system, as expressed in the following interview extracts: "*EPMS has the highest number of active compared to the pharmacy*", and also as indicated by the participants: "*people don't know which one to trust*". In the requirement theme, the researcher also included the participants' need for a common report from EPMS and EDT as alluded to by the following interview extracts: "*we want to validate, we have to have the correct number of active patients basically*", "*we always compare new patients on ART and active patients on ART from the EDT system. So, I think it's important for the systems to generate the same report*s". Furthermore, the researcher also included opportunities to form part of the requirement theme as it can be used as a drive to the solution to be developed. This includes things that are part of the "common data" code, as indicated by the participants: "*is the unique number that the systems shares"*. The participants' feelings on how common data can help in terms of data capturing were picked during the data collection as alluded to in the following extracts: "*Yes, because in most of* *the time, it will prevent mistakes from miss-entering of patients' details, demographic details, so if the systems are connected, you can only enter in one system and just share the information*".

Political interest is a theme that was adopted to represent data that highlights the factors that might influence the development of the interoperability solution. This is specified in the following interview transcripts, "*EDT has in-transit patients that are not captured in EPMS", "We also have patients that sent their treatment supporter to collect their ARV medication for them",* and *"It's mostly because of the indicators. Each system measures different indicators, so that makes it difficult to measure or collect same indicators*" which indicates differences in operations that need to be ironed out if we want EPMS and EDT to produce a common report. Furthermore, the stakeholders that are maintaining EPMS and EDT systems are fighting to protect their market niche as indicated by the following interview extracts: "*The problem lies with the different NGOs that are handling the systems, most of the programmes are donor-driven.", "Each donor does not want to give up their system. The one with EPMS wants to keep EPMS and the one with EDT wants to keep EDT*." The political interest includes the governance of HIS in place that needs to adhere to as the participants indicated that the ministry has ICT policies as evidenced from the following interview extracts: "*the ministry has a standard, but most of the programmes are donor-driven."* Participants also indicate that: the *"MoHSS HIS department relies on the ICT standards maintained by the OPM*." This theme also included the lack of funds to invest in health information systems, thus the ministry relies on donor funds as indicated by the following extracts: "*The ministry does not have funds to get in new systems that's why they depend on the donor*", of which the researcher thinks that it needs political buy-in, support, and recognition for the resources to be allocated to EPMS and EDT interoperability as well the development of e-health.

The technology theme includes data on EPMS and EDT systems' platforms. This includes the software the systems are developed in, which was used to determine the type of software that can work well with the available technology. This is because EPMS and EDT systems are heterogeneous, whereby "*one system is on SQL [EDT]and the other one is on FileMaker [EPMS]"* as indicated by the participants.

Infrastructure was also adopted as a theme. The researcher picked up that infrastructure is a real challenge in Namibia, and it might impact the development of the interoperability solution. This theme was mentioned in all four interviews that were conducted during the data collection. This is what the participants had to say about the MoHSS's ICT infrastructure: "*they [facilities] don't have WIFI access* *or something like that, it will be very difficult, and the EDT is not web-based yet. So, it will be very difficult.", "They can only run on standalone. they are not on the same network and they are not in the same room. The building can be the same. But the EDT system it's not connected on the ministry's network", "EDT is just a desktop application, offline application", "Not all the facilities have internet*."

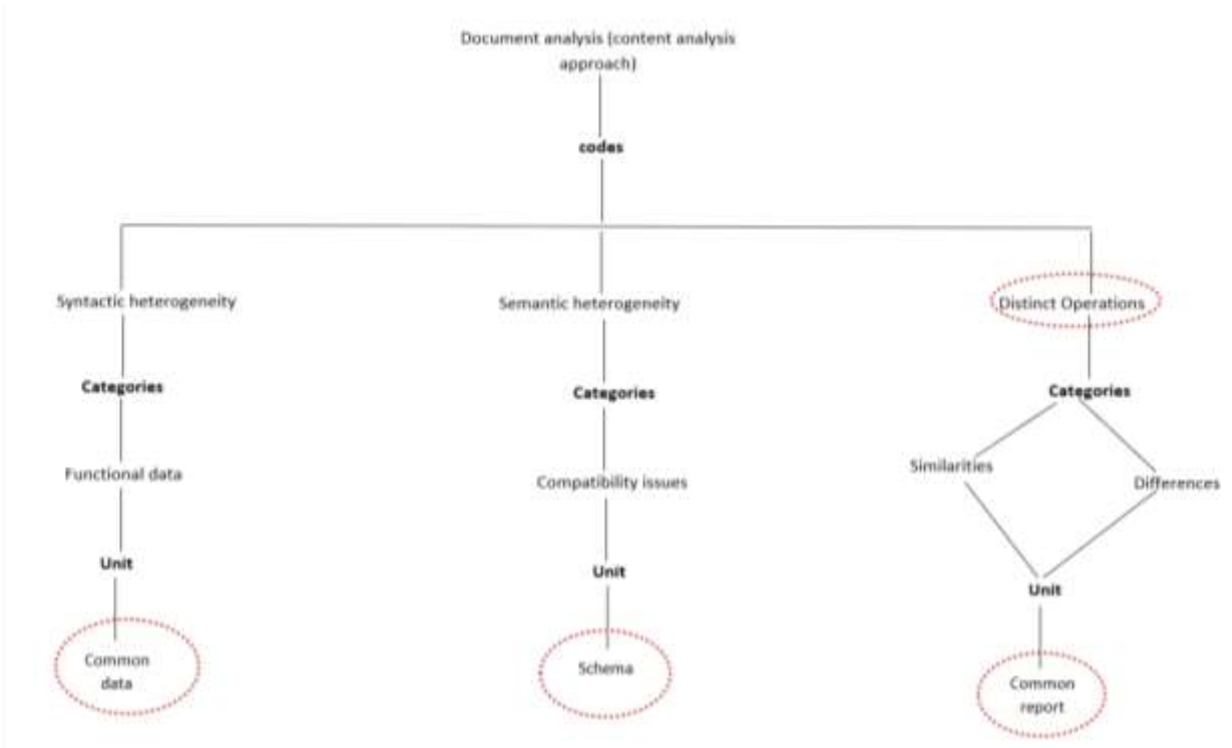
The final theme was the proposed solution. This theme aimed to highlight the participants' understanding of the challenges that need to be addressed. Furthermore, this theme represents the participants' contributions to what type of solution they think will solve their current challenges. The proposed solution from participants includes, "*it's either we reengineer the technology in the old system or we update it to a new software for the two systems to be speaking to each other", "The best way is if the systems are running on one platform, So, if we can be able to find a third party, even a software, can happen if we are having both systems which are running on the same infrastructure and the same network".*

The researchers' main takeaways from the semi-structured data analysis process are that the participants understand that EPMS and EDT interoperability will be suitable solutions to their challenges. This provided confirmation that the solution being explored to address EPMS and EDT challenges as defined in the research's problem statement can make an impact in their daily activities. The researcher also picked up that EPMS and EDT system's challenge to produce a common report is caused by multiple reasons. This includes incomplete records, distinct operations, and the difference in indicator definitions. These findings helped the researcher to answer one of the research sub-questions which is "how can the EPMS and EDT systems produce a common report?". The researcher also picked up that systems interoperability is not entirely technical, thus sociotechnical issues need to be highly considered if EPMS and EDT systems are to interoperate. This includes defining the interoperability scope whereby the systems' roles in interoperability are defined for all organisations to understand and support the interoperability idea without fear of losing their function. Furthermore, it was noted that the HIS is governed by ICT standards that are maintained by the OPM, therefore, the OPM office should be involved to ensure that the solution is adhering to the available ICT policies. These findings contributed to providing the answer to what processes are required to integrate EPMS and EDT systems. On the technology theme, the researcher made use of this data to plan and design how the solution can be developed in a way that it can be supported by the available ICT infrastructure. The technology theme guided the research on finding the solution that is suitable for both EPMS and EDT platforms.

4.4 Data Triangulation

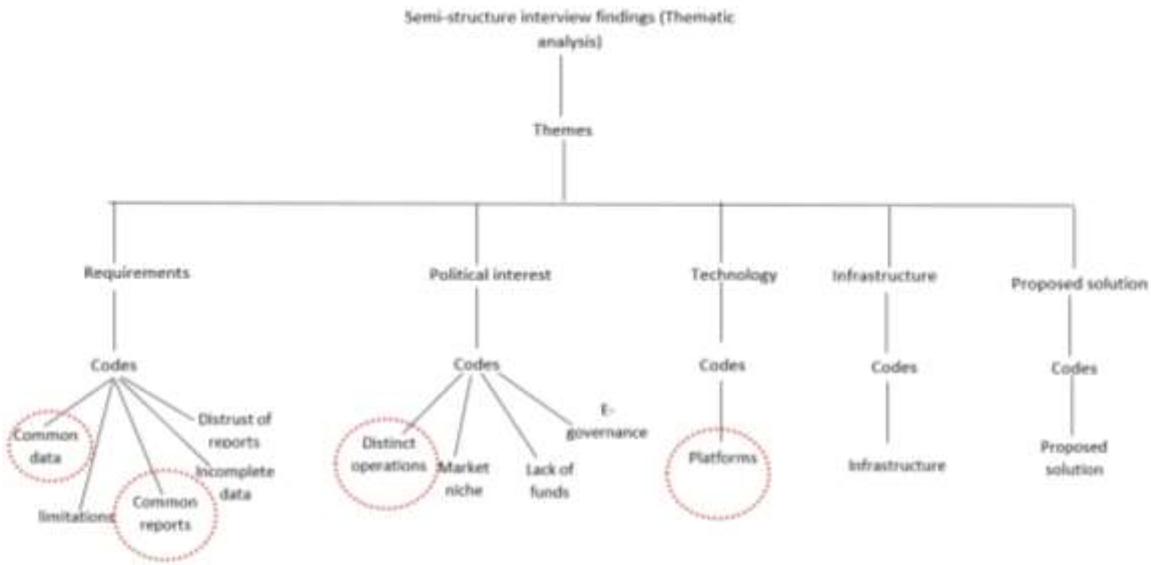
Two data analysis approaches were used to analyse the data on the requirements for the EPMS and EDT systems interoperability solution. For the content analysis, the research identified a sample of content to analyse data based on the research questions. The units were chosen with the influence of the researcher with the guidance of the research questions on how the categorisation of units was carried out. The findings from the content analysis were based on how the selected concepts are described and presented in the user manuals and data dictionaries. The only bias influence on the content analysis results is the perspective of the researcher which was used to sample the content that is based on the research questions. The findings from the semi-structured interviews were solely based on the participants' inputs on the challenges they are currently experiencing with both EPMS and EDT systems in terms of data, both completeness and reporting, and why they think the EPMS and EDT system should interoperate. The participants also mentioned why they think that data exchange between EPMS and EDT in their current state would be a challenge. The researcher only generated the codes based on the interview extracts of the participants which are presented with quotes on the thematic analysis report. Themes were generated to represent the participants' inputs. The researcher compared the two findings achieved using two completely different approaches. Similar findings were used to provide a cross-verification of the results obtained, while results that were only obtained through one method of data analysis provided a new perspective on the findings which the researcher could have missed out if only one form of data collection was used. Below are data analysis diagrams for content and thematic analysis to compare the findings.

Figure 4.1: Content Analysis Approach



This diagram shows a bottom-up process of a content analysis approach, whereby a conceptual data analysis method was adopted to analyse data. Firstly, the units are identified, then categorised based on the research questions. After the categorisation, coding rules were developed to be used in coding the content analysis results. The requirements circled in red are found to be similar to the requirements generated by the thematic data analysis process.

Figure 4.2 Thematic Analysis Approach



The diagram above displays the process of thematic analysis and its findings in the form of themes. The codes represent the participant's extract from the interviews, which were later represented by the themes. The codes highlighted in red are found to be like the units that were identified during the content analysis approach. The comparisons revealed similarities in the codes from the thematic analysis and units from the content analysis. The matching requirements include common data, common reports, and platforms. The similar findings are circled in red. Other findings selected from thematic analysis only include market niche, lack of funds, e-governance, and infrastructure. These findings represent interview participants' inputs that the research managed to pick up through interviews only.

4.4 Chapter Conclusion

Content analysis was used to analyse data collected through document analysis. A conceptual data analysis methodology was used to review a targeted sample of content according to the research questions. The findings of the content analysis are highly influenced by how the data collected is described in the user manuals and the data dictionaries. The data collected through semi-structured interviews were analysed with the thematic analysis approach. The researcher concentrated on the items that were picked up repeatedly from the interview transcripts that were converted to codes. The different codes that had the same patterns were converted into themes that represent the requirements of the EPMS and EDT system interoperability model development.

Chapter 5: EPMS and EDT Systems Interoperability Model

5.1 Introduction

This chapter explains the methodology adopted that enabled the design and development of the EPMS and EDT systems interoperability model. The model was developed based on the actual data analysis findings from the two main data collection methods employed in this research, which are the document analysis (an analysis of relevant user manuals and technical documents) and interviews conducted with DSP, HIS, and pharmaceutical departments. The research adopted the design science research theory as the main design and development approach. This chapter is organised in the following manner: first, the seven guidelines of the DSR and how they are applied in the development of the model, the elements of data analysis included in the development of the interoperability model, the research's contribution to the research problem, EPMS and EDT systems' data integration process, EPMS and EDT interoperability model and lastly the EPMS and EDT interoperability model development.

The development of the interoperability model was achieved by applying the seven guidelines of design science research theory according to Hevner et al. (2004).

1. Design an artefact
2. Problem relevance
3. Design evaluation
4. Research contribution
5. Research rigor
6. Design and evaluation
7. Communication of the research

The researcher found the seven guidelines of design science research very useful to the research because they are theoretical ideologies that assisted the researcher to explain the outcomes of the methodology in the form of a model, how it will be interpreted and its reliability to the reality of the research problem. Chapter one of the research covered stages one and two where the research presented the research problem statement and motivation as well as the overall aim of the research and the research's objectives. Therefore, in the present chapter the research is at the stage of design and development in which it explains how the interoperability model was achieved.

5.2 Content and Thematic Analysis Findings

The research concluded that EPMS and EDT systems are incompatible at many different levels. This includes syntactic, conceptual, terminology heterogeneity as well as in terms of few clinical operation discrepancies. However, EPMS and EDT systems share a wide range of common input fields that can solve their data incompleteness issues as the common data fields can be captured in one system and share with the other system. This includes the patients' main unique identifiers. Furthermore, the MoHSS's HIS department relies on the ICT governance standards and policies that are established and maintained by the OPM. However, most of the policies established are not operational as they are still under cabinet review. Moreover, all the MoHSS's health information systems are developed and maintained by donors that provide their own system requirements based on their project reporting needs and interests. In terms of ICT infrastructure, both EPMS and EDT systems are standalone databases. The EPMS system is on the MoHSS's network at district hospitals and selected health centres. On the other hand, EDT is on a private network at the district hospitals and uses offline devices to collect data from health centres and clinics.

5.3 Research Contribution

The aim of the research was to provide an interoperability solution in the form of a model of EPMS and EDT systems without redesigning the current architectural designs. Therefore, for that reason, the research provided an interoperability solution through achieving data and application integration between heterogeneous systems, EPMS, and EDT systems through a model. Generally, system interoperability is a complex concept, especially when the systems involved are heterogeneous as they require more time, advanced skills, and more resources. To achieve the research objective, seven guidelines of design science were followed to enable the research to achieve interoperability through adopting an integrated data model. In this research, this model is referred to as a canonical data model. Various common data fields from the systems that form part of the interoperability solution are mapped to create a unified view. This approach also allows a context-sensitive behaviour of functional systems integration through the use of minimal semantic technologies.

5.4 Data Integration Process for EPMS and EDT Systems

The data integration process for EPMS and EDT systems involves guidelines in the form of steps to be followed to achieve interoperability between EPMS and EDT systems. These steps enabled the researcher to determine the fundamental requirements to integrate data for both EPMS and EDT systems and the processes to be carried to achieve the interoperability objective.

5.4.1 EPMS and EDT Data Integration Steps.

Step 1: Determining Data Integration Requirements

The aim of this step/process was for the research to be able to identify and determine what the data integration requirements for EPMS and EDT systems are. Therefore, to determine the requirements of the data integration model for EPMS and EDT systems, several analyses were carried out. The first analysis that was conducted to determine the relevant requirement for EPMS and EDT data integration was by conducting an "as_is" process analysis and a detailed process analysis. In this research, the "as_is" process analysis is a process of conducting a high-level overview of the current "as_is" situation of the EPMS and EDT systems in terms of the HIV care process (Fernandez et al., 2018). The "as_is" process analysis was further broken down into smaller processes that enabled the researcher to get a better picture of the EPMS and EDT systems' current process situation. This includes the process analysis, the use case analysis, and the organisational analysis.

Step 1.1 The "As_Is" Process Analysis for HIV Care Programme

The "as_is" process analysis firstly assisted in identifying and determining the relevant HIV care processes carried out by EPMS and EDT systems that enabled the research to achieve its objectives as emphasised in chapter one of this research.

The HIV care treatment processes supported by the EPMS and EDT systems and relevant to the research's objectives are as follows:

a) Patient registration on the HIV Care Programme

Patient registration on the HIV Care Programme starts by opening a physical patient file, known as the Patient Care Booklet (PCB) for a patient whose HIV status has been confirmed to be positive. An authorised administrative clerk is tasked to assist the doctor/nurse with capturing the data on the

EPMS system from the patient’s care booklet. During the patient registration on the EPMS system, the data captured on the system includes demographic information of the patient, treatment supporters, and the contact details for both the patient and their treatment supporter. Information on the community-based organisation is also captured as part of the patient registration process. The same information is collected using an EDT system patient recruitment form by a pharmacist, who will then capture the same information from the PCB onto the EDT system which is the pharmacy tool that deals with patients’ medication dispensing. This information is captured on the EDT system only if the patient has started taking ARV medication.

b) Patient initiation on ART treatment

Here, the patient's ART initiation information is recorded in the Patient Care Booklet known as PCB, which will then be captured on the EPMS system. The clinical information includes the patient’s HIV confirmation date, ART start date, ART start regimen, and Baseline information. The baseline information includes but is not limited to the weight and height of patients at ART initiation, their clinical stage, and Function.

c) Patient treatment follow-ups

Here the patient's ART care visits are recorded in the PCB which will be captured on the EPMS system. The patient’s visit data that is recorded in the PCB includes the patient’s actual visit date and the next follow update. The next follow update indicates when the patient is expected to come for the next clinical visit. Apart from the next following date, the patient’s current weight, height, functions, clinical information, and current ART regimen are also recorded during the patient’s visits.

d) Patient registration for ART dispensing

After ART initiation, the patient’s PCB is then forwarded to the pharmacy for the patient to register on the EDT system. At the pharmacy, the patient information is collected using a form called the ART recruitment form before being captured on the EDT system. This includes Unique Identifying information (full name, pharmacy number, d.o.b, sex), contact details for both the patient and the treatment supporter, clinical information, and ART start regimen. The patient is also given a follow update known as the “next pill pick-up” date.

e) Generates reports: Both EPMS and EDT systems generate reports on similar, related, and different indicators. These reports include but are not limited to, patients currently active on ART treatment, patients' current ART regimen, newly started on ART, etc.

After the identification of the HIV care processes in line with the research's goal, a more detailed process continued through use case analysis.

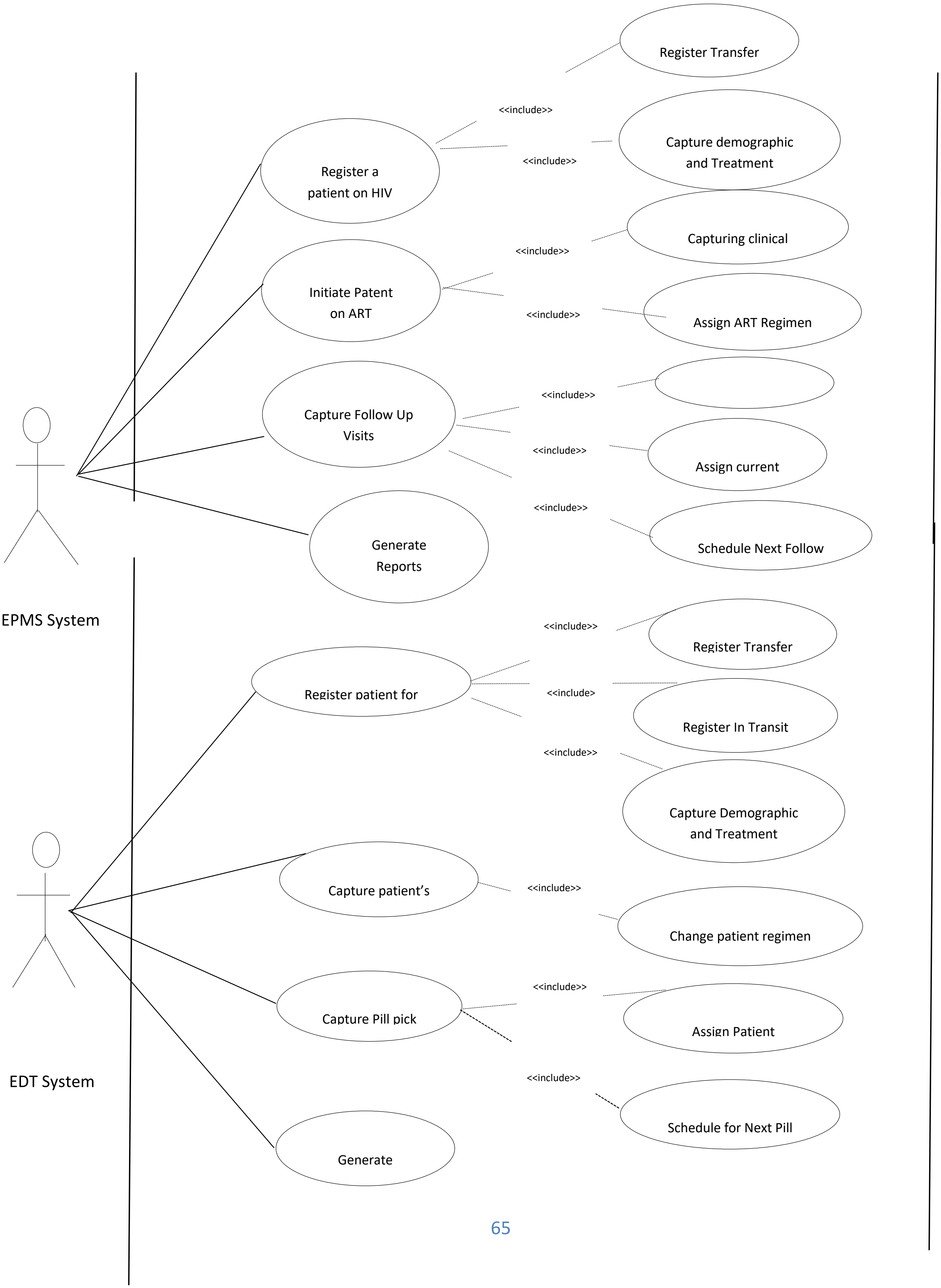
Step 1.2 HIV Care Use Cases for EPMS and EDT Systems

A use case is a representation of how the system interacts with its environment by providing outputs based on the inputs from the system's users (Cacoo, 2018). The use cases are based on the ultimate process goal and they are functional requirement focused. In software development, the use case analysis is a primary method of user requirement gathering, organising, and analysis for a new software program or a system (Nishadha, 2018). This research found the use case analysis method suitable for process analysis and functional requirement analysis for the design and development of the data exchange model of EPMS and EDT systems.

Key components of a use case (Lynch, 2019) are as follows:

a) Actor: These are entities that use or are being used as input by the system that operates from outside of the system boundary. Actors represent a person or an organisation with a role in a system.
b) Use case: Represents an activity or function that happens within the system's boundary.
c) Relationships: Indicates the associations or links between actors or between use cases.
d) System boundary: The system boundary illustrates the scope of the software, framework, or system.
e) Actors: EPMS and EDT systems

Figure 5.1: EPMS and EDT Systems Use Cases



HIV Care Programme Organisational Analysis for Process Supported by EPMD and EDT Systems

Here all roles and responsibilities within the company are highlighted. This only includes the roles that are related to the HIV Care programme that is supported by EPMS and EDT systems, which were already defined in the use cases earlier.

The researcher identified the main three roles of the HIV care programme that are relevant to EPMS and EDT systems, namely:

a) Register patients on the HIV care programme. Here, every patient confirmed to be HIV positive is registered on the HIV care register that available at all ART sites. During patient registration, a healthcare worker opens a Patient Care Booklet (PCB) and assigns a unique ART identification number for each patient. The admin officer registers a patient on the HIV Care programme on the EPMS system using the patient's care booklet as the primary source of patient data.
b) Initiate patient on ART. This role is performed by a healthcare worker whereby the patient's clinic data is recorded on the patient's care booklet. The clinical data includes but is not limited to HIV positive confirmation date, HIV enrolment date, ART start date, ART regimen, etc. The admin officer uses the documented patient care booklet to capture the patient's clinical data, capture the ART start date to initiate the patient on ART treatment, and to assign the prescribed ART regimen as documented in the PCB. This patient care booklet is forwarded to the pharmacy, where the pharmacist registers a patient on EDT and captures all the required clinical data as documented in the PCB.
c) The assessment of patient response and progressiveness on ART treatment
The patient's progress and responsiveness to HIV and ART treatment and care are done through scheduling follow-ups and conducting different laboratory tests at specific intervals. These measurements are firstly documented in the PCB and later forwarded to the admin officer and pharmacist to be captured on both EPMS and EDT systems.

Step 1.3 A Detailed Analysis of HIV Care Program

A detailed analysis continues from the rough analysis by broking down the "as-is" processes into more detail as identified earlier in the use cases. The detailed analysis is also divided into four processes. This includes input-output analysis, system analysis, data source identification, and data object identification. The detailed analysis process helped in obtaining more understandings of the research requirements by studying the HIV care processes that are supported by both EPMS and EDT systems, EPMS and EDT systems, and its IT support in more detail.

a) Input-Output analysis process

Input-Output analysis is a method of macroeconomic study which primarily focusses on determining mutual dependencies between various sectors to estimate the impacts of economic uncertainties and analysing the current economic effects (Kenton, 2020). However, recently the input-output analysis is broadly used openly in various fields, including information systems engineering and development (Kenton, 2020). Therefore, in the field of system engineering and development, input-output analysis is mainly used for understanding and engineering the functional requirements for a new IT product or system.

The input-output analysis process was found crucial to this research as it enabled the research to break down into more detail the essential functional requirements that are highlighted in the use cases analysis conducted earlier as part of the "as -is" rough process analysis. The input-output analysis further helped the research to identify the factors influencing the identified use cases. The input-output analysis section is organised in the following manner: firstly, the inputs and outputs of the HIV care programme that are part of the use cases were identified. After that, a detailed description of all the inputs and outputs generated by the HIV care programme use cases identified earlier is compiled.

Table 5.1: HIV Care Programme Input-Output Analysis

Inputs	Outputs
○ MoHSS HIV care policies, procedures, standards, and guidelines ○ Human resources ○ Finances ○ Organisation and Management	○ Information, reporting ○ Service quality and availability

HIV care programme inputs and outputs description according to the HIV care programme use cases

a) All the use cases related to HIV patient registration, initiation, and continuous ART patient treatment and care are done following the MoHSS's policies, procedures, and guidelines in line with the WHO HIV care standards.
b) Human resources include nurses, doctors, and pharmacists, as well as the data clerks that capture HIV care information.
c) Finances are an indirect input but a very crucial input factor. This involves making sure that all the workers involved get paid, as well as the procurement of medications, medical equipment, computers, and the software needed for HIV care programme data collection.
d) Organisation and management are also indirect input factors. Although all the hospitals follow the same HIV care procedures and guidelines, different facilities develop ways to make their daily operations easier. This includes when they get to perform certain events, for example, laboratory activities, as not all the facilities have laboratory premises in their ART facilities, especially small clinics. This can also include facility initiatives on improving patient service quality and delivery for their facilities.
e) On the outputs, information and reporting are the major outputs for the HIV care programme; this is because in healthcare, "if it's not documented, it was not done" (Russell, 2019). The information produced can also be used as knowledge to shape health actions and decision making.

f) Service quality and availability are also part of the major outputs of the HIV care programme.

b) System analysis process

Generally, system analysis is a process of studying and understanding in detail a system by studying the business processes that are supported by the system, collecting facts about the system and the data collected by the system, identifying problems and challenges with the system, and providing useful recommendations to improve the system's functionality and efficiency (Gustas & Gustiene,

, 2020).

The system analysis process played an important role in this research by ensuring that all the applications and systems supporting the HIV care programme processes are identified. Furthermore, the system analysis process helped the research to understand the HIV care processes that are supported by EPMS and EDT systems in detail and identified the problems associated with these processes that collect the data to be exchanged. The use cases that are supported by two systems are broken down to ensure that each use case is supported only by one system. This system analysis process helped the researcher to understand the process or data flow between systems supporting HIV care programmes and recommended which data should be collected using which system and eventually shared with the other system as part of our interoperability initiative. First, all the systems used within use cases were identified as well as events that trigger those processes. Event triggers are actions that prompt an event to execute (Xu et al., 2019). In other words, event triggers are responsible for starting or ending business process.

Table 5.2: Systems Use Cases and Event Triggers

HIV care use case	**System(s)**	**Event trigger(s)**
○ Patient registration on the HIV Care programme	EPMS system	HIV enrolment date
○ Patient initiation on ART treatment	EPMS system and EDT system	ART Start date

○ Patient treatment follow-ups	EPMS system	Follow update
○ Patient pills pick-up date	EDT system	Pill pick-out date
○ Reports generation	EPMS and EDT systems	

In the table above, some of the use cases are supported by two systems. For example, the patient initiation on ART treatment data is captured by both the EPMS and EDT system. This use case needs to be broken down further so that it is only supported by one system. From the use cases, the process flow starts from the EPMS system, where the patient is initiated on ART treatment first before being referred to the pharmacy for ART initiation and medication dispensing on the EDT system. Therefore, in terms of interoperability between EPMS and EDT systems, the similar data captured by the systems need to be captured by only one system and forwarded to the other system, which is the ultimate goal for this research.

After the system analysis process, the data source identification for HIV care use cases is done.

c) Data source identification

A data source identification is a process of identifying the systems that collect and store data that is part of supporting business processes (SolveXia, 2019; Samuelsen et al., 2019). Thus, to accurately understand and interpret data for a better interoperability solution, one must be mindful of real data origin.

The objective of the data source identification process is to identify which applications and systems provide the inputs to the HIV care programme use cases. This helped the research to determine which system contains the most accurate, relevant and complete data that can be considered as the primary source for data for the mapping process of the data integration.

To determine the most relevant data source that provides the inputs to the HIV care use cases supported by EPMS and EDT systems, it’s essential to know the purpose for all the systems involved.

Thus, for this research, all the use cases are supported by EPMS and EDT systems. The main purposes for the EPMS system are to collect, store, and report on HIV care and ART treatment, while the EDT system is ART medication dispensing and reporting. The purposes for EPMS and EDT systems are not entirely the same, but they complement each other because both systems administer similar patients. Therefore, the data source identification process for this research was challenging because both EPMS and EDT systems used homonyms and synonyms. To avoid selecting an incorrect data source or ambiguity in meaning, the common and different terminologies need to be well studied, and this can be achieved through exploring the data object identification process.

d) Data object identification process

Data objection identification is a process of exploring data orientation by identifying and understanding the data requirements of the business processes at a level of the system (Zhao et al., 2019). Data object identification is a key process in multiple data source integrations. This is because when the data sources administer similar or related data there is a high possibility of the same data being presented in various inconsistent formats. Therefore, the data object identification is performed in this research for data field classification. The data object identification helped the researcher to identify and define the required data requirements for EPMS and EDT systems. The data objective identification process further assisted the researcher to gain a clear understanding of the syntax and semantics of what the EPMS and EDT input data fields are representing and their formats.

EPMS and EDT systems' data objects can be fully understood by exploring both systems' metadata. Metadata is data that describes other data by its meaning and properties (Data-Driven World, 2019).

For EPMS and EDT systems' metadata of common input data fields see table 4.1 of the research findings chapter. Below, EPMS and EDT systems' inputs data packages to the HIV care use cases are identified.

Table 5.4: EPMS and EDT Data Packages

System(s)	**HIV care Use case**	**Inputs (data packages)**
EPMS	Patient registration on HIV care programme	○ Demographic data (Full Name, Unique ART number, D.O.B, gender, Pharmacy number, Address, and contact details)

		○ Treatment supporter data (Name and contact details) ○ HIV enrolment data (confirmed HIV positive date, HIV enrolment date, weight, height, clinical-stage, CD4)
EPMS	Patient initiation on ART treatment	○ Clinic data (ART start date, ART initiation regimen ○ ART baseline data (weight, height, CD4, clinical-stage, function)
EPMS system	Patient treatment follow-ups	○ Clinical visit date ○ Next, the follow-update ○ Patient's current clinical data (current weight, height, function, clinical-stage, current ART regiment, current patient status)
EDT	Patient registration for ART dispensing	○ Demographic data (Pharmacy number, unique ART number, Full Name, DOB, gender, contact details, address) ○ ART start date ○ ART start regimen ○ Treatment support details (name, address, and contact number)
EDT	Pill Pick-Ups	○ Pill pick update ○ Current regimen ○ Current patient status

Step 2: Determining a Suitable Data Integration Approach for EPMS and EDT Systems' Interoperability Model

This step aimed to define the data integration approach by identifying the data sources and the target sources to be part of the interoperability model. Furthermore, EPMS and EDT systems' interoperability limitations and opportunities were identified as guidance on the suitable integration approach.

Step 2.1 Target Definition

Now that the interoperability model requirements for both EPMS and EDT systems are defined through both the rough analysis and detailed analysis process, it's time to start with the design and development of the interoperability model between EPMS and EDT systems through the target definition process.

Target definition is the process of defining the new interoperability landscape as a bridge across all data sources involved in the data exchange process (Torgersen, 2017). During the target definition process, the data sources for the interoperability solution, and the targets are identified. Once the data sources and targets are identified, the exchange format is defined. The interoperability exchange format is a standard interface architecture that can be used between EPMS and EDT systems to share data among themselves. Data exchange format can be either active (online data sharing, for example, web services) or passive (offline or partially connected, for file sharing) (Torgersen, 2017). Here are the factors to be considered when selecting the EPMS and EDT data exchange format.

(a) EPMS and EDT systems' back end structures, mainly in terms of semantic and syntactic.

EPMS system is a Filemaker software for both the back end and front-end architectures. EPMS database is un-normalised and a group of related data fields from various entities which is saved in the same tables. Furthermore, the EPMS system's tables are all linked with one primary key which is also the main patient identifier on the system. While on the other hand, the EDT system is a combination of Microsoft Access for the front end and SQL for the backend structure. EDT has a normalised back-end structure and each table has its primary key, which is different from the patient's main identifier. For data exchange to happen across systems, it is highly required that these systems have some level of compatibility among them. System compatibility is when two or more systems of the same or different software can operate satisfactorily together without being transformed to do so . EPMS and EDT systems have completely different platforms and back end structures. This means that at this point, EPMS and EDT systems cannot share data without being altered to do so, which means that the two systems are not compatible. Therefore, there is a need to explore how EPMS and EDT systems can be altered to exchange data.

(b) EPMS and EDT opportunities

EPMS and EDT systems are all MoHSS systems that administer similar patients. EPMS and EDT systems share a wide range of common fields that in most cases are available in one system but empty or incomplete on another system. These systems are used for data quality assessments at district levels comparing the total number of ART patients actively on treatment in terms of monitoring and care from the EPMS system against the total number of patients actively receiving their ART medication from the EDT systems. Furthermore, EPMS and EDT systems share similar and complementary reports that are supposed to fill in the gap which is important for healthcare interventions and decision making.

(c) EPMS and EDT systems' interoperability Limitations

There is a huge degree of heterogeneity between EPMS and EDT systems in terms of their backend structures. There is also extensive use of incompatible ontologies and terminologies in both EPMS and EDT systems. The EPMS system is known as a legacy system in HIV care and treatment, as a result, this system has limited interoperability capabilities. Both EPMS and EDT systems were developed in fulfilment of the project's or donor's interests (Dlodlo & Hamunyela , 2017). EPMS and EDT systems are fragmented and operate in silos (MoHSS HIS Assessment Report, 2011). Besides, the MoHSS's HIS reported that their systems have unreliable data, and EPMS and EDT systems are no exception . Moreover, there is a lack of common patient identifiers in EPMS and EDT systems. Moreover, the MoHSS's ICT infrastructure is reported to be poor (MoHSS HIS Assessment report, 2011).

(d) EPMS and EDT systems' interoperability scope

The main goal of this research was to design and develop an interoperability model for EPMS and EDT systems in their current states. Therefore, a methodology on how EPMS and EDT systems can be integrated to share data through a model is explored.

Step 3: Determining a Data Exchange Model and Data Exchange Approaches

This step aimed to determine a data model that best fits the EPMS and EDT interoperability situation and how interoperability between EPMS and EDT systems is achieved through a suitable interoperability approach.

Step 3.1 Data Exchange Format for EPMS and EDT Systems Interoperability Model

After identifying the opportunities, challenges, and the scope of the EPMS and EDT interoperability model, this information is used in designing the data exchange format that complements those factors. For data exchange of systems with completely different platforms and structures, it required interoperability to be achieved at different levels. Therefore, the researcher found it fit to introduce a data exchange format in the form of an information model. An information model is a logical representation of a concept stating how the content is organised and specifying the data requirements of the application domain. The concept highlights its relationships, limitations, rules, and operations to specify the data semantics for a chosen domain disclosure (Namli et al., 2019).

Steps to follow to achieve an information model for EPMS and EDT systems (Namli et al., 2019)

a) Determine the translation approach

Here the researcher identified how the data from two heterogeneous systems will be communicated and understood by the systems to exchange data. The data translation approach was important for this research because EMPS and EDT systems are developed and managed by different organisations. Thus, both systems have completely different backend structures. However, data integration or systems interoperability requires a level of compatibility that can enable the systems to communicate among themselves. Therefore, it is essential to build and maintain a data translator that can act as a mediator to facilitate the meaning of data from EPMS to EDT systems and vice versa. This can be achieved by introducing a unified view by creating a mapping of all the required common data fields of EPMS and EDT systems.

b) Apply a single vendor mandate approach

This approach recommends that the interoperability solution be developed by one company aiming for interoperability or data integration goals. Therefore, the interoperability steps and processes for the EPMS and EDT system recommended by this research can be used as guidance to develop and build the model for data exchange by following the steps and process followed in the development of the interoperability model.

c) Identify the information exchange standard mandate approach

A standard approach is used for integrating the systems to share data. Information exchange standards are chosen based on interoperability requirements. The data integration approach is used as a standardised approach to design an interoperability model of EPMS and EDT systems. The data integration was chosen based on EPMS and EDT systems data exchange requirements.

Step 4. EPMS and EDT Systems Information Model

To determine a fitting data exchange model for EPMS and EDT systems, it is required that the interoperability limitations and opportunities identified earlier for both systems to be highly considered. The data exchange model should be able to address these limitations and take advantage of the opportunities. Therefore, a bi-directional data exchange format is adopted for the EPMS and EDT systems interoperability solution. The bi-directional data exchange format was achieved by creating a fully integrated technique where EPMS and EDT systems share common data via a conceptual global schema. A global schema is a unified view of common data from the systems that are involved in the data exchange process.

For data synchronisation between the data exchange model and EPMS and EDT systems, the research explored the replication approach. Replication is a bi-directional method of data synchronisation that supports an offline environment (Torgersen, 2017). Here, the data is copied from EPMS and EDT system back-end repositories into a global schema, which is the interoperability model. The data synchronisation between the interoperability model and the systems will happen in a batch data integration manner. A batch data integration method allows sending and receiving data from the global schema to the data sources and vice versa to happen periodically, on a daily, weekly, or monthly basis.

The bi-directional data integration approach was found suitable for EPMS and EDT data integration for the following reasons:

a) The data exchange format adopted by this research will achieve schema conflict resolution by adopting a fully integrated bi-directional data exchange approach, that allows the creation of a unified view of common data fields from EPMS and EDT systems identified earlier.
b) The bi-directional data exchange format will keep EPMS and EDT systems in sync, which will result in complete records which is an ongoing challenge currently faced by both EPMS and EDT systems.

Step 5: Data Extraction, Transformation, and Loading (ETL) Plans

This step aimed to determine the data extraction process from EPMS and EDT into the unified view and how the extracted data is transformed to match the required format and as well as highlighting the data loading plans.

Step 5.1 EPMS and EDT Data Extraction, Transformation and Loading (ETL) Plans

In data integration and systems interoperability where different multiple data sources are involved, it entails the ability to obtain the required data from its source and converting it into a compatible format with the target source (s) where it's well recognised. Thus, for EPMS and EDT systems to share data, the most suitable data extraction, transformation, and loading approaches are compiled.

Step 5.2 Data Extraction Approach for EPMS and EDT Systems

EPMS system is a Filemaker software that stores unstructured data. On the other hand, EDT is a combination of MS Access and SQL that stores structured data. Both systems have completely different platforms. Therefore, the research explored an ETL approach that is suitable for both EPMS and EDT platforms which in this case is Filemaker and SQL software environments. Filemaker software supports a data extraction functionality known as Open Database Connectivity (ODBC) or Java Database Connectivity (JDBC) when EPMS and EDT databases are on the same computer or via the same network. This functionality works with several programming languages such as Oracle, SQL, and Java, in which the data extraction queries are designed to only include specific data fields of interest. The research found the ODBC/JDBC Filemaker functionality suitable for the EPMS and EDT data integration extraction because it allowed the importing and exporting of data in batch operations using either SQL or Java queries. The data extraction queries are designed to identify and extract the common data fields only for both EPMS and EDT systems.

Every patient on HIV care is assigned with a unique identifier. All the patients' data on the EPMS system is embedded in the unique identifier known as the unique ART number. The unique ART number is also captured on the EDT system; therefore, it will be used as the main patient identification for both the importing and exporting of data to identify the patient's data for this interoperability model.

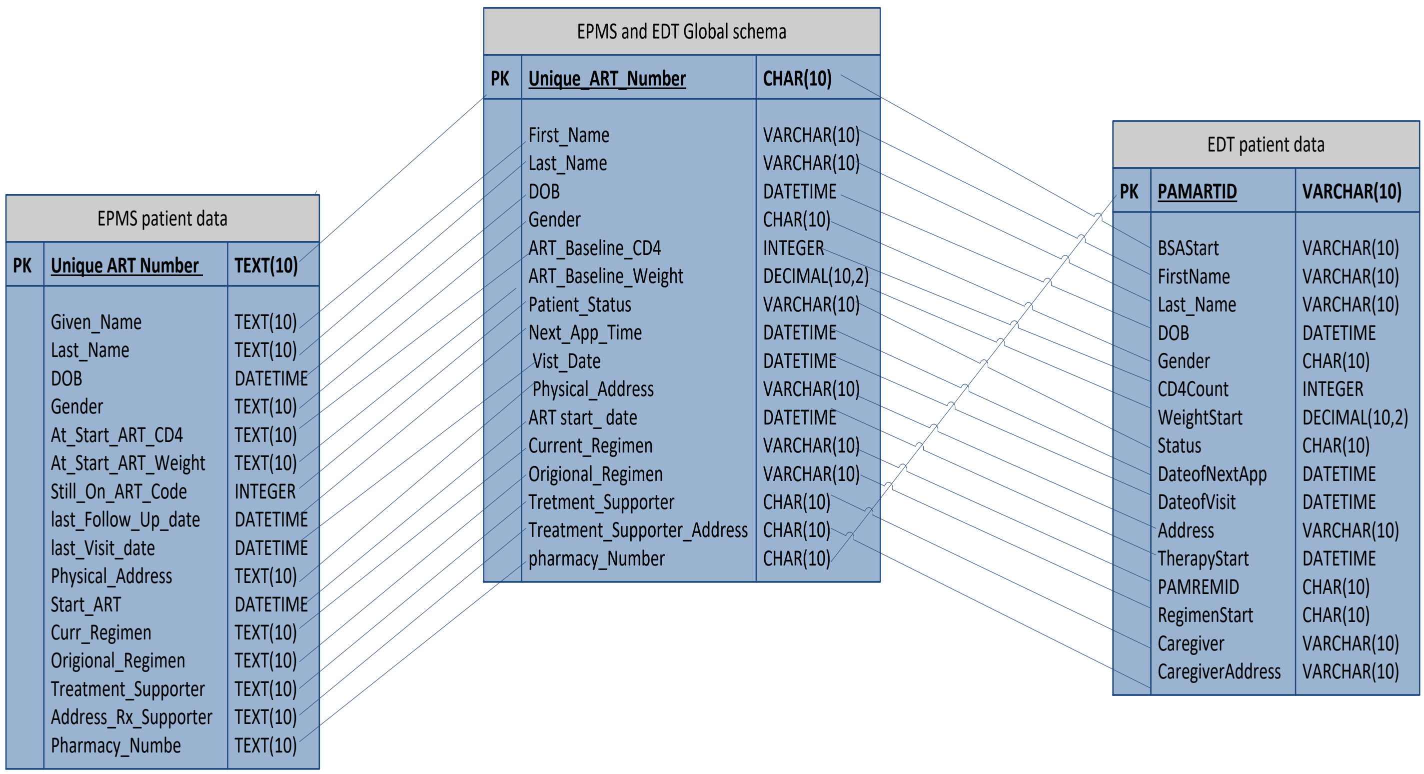
After the data is extracted from its sources, the data needs to be transformed. This is crucial when the data to be extracted is from different sources and in different formats. This helped the researcher to resolve semantics conflicts and ambiguity in the meaning of all data fields involved. Therefore, for the data consolidation to be successful, the data needs to be transformed first.

Step 5.3 Data Transformation for EPMS and EDT Systems

EPMS and EDT data transformation was achieved through the process of data mapping from the original to the desired format. The data transformation happened before the data was extracted into the global schema.

The diagram below shows how common data fields are integrated for the EPMS and EDT interoperability model.

Figure: 5.2 EPMS and EDT Common Data Fields Mapping



EPMS and EDT data exchange does not require all fields to be transformed, especially fields that are stored in a text format, and the desired format on the global schema is Varchar. However, some data fields require to be converted into the desired format, for example, the field “Still_On_ART_Code” is a number (integer) in EPMS and it is stored as a character in EDT. On the other hand, on the unified schema, the “Still_On_ART_Code” is assigned to a text. The figure below demonstrates a logical presentation in SQL on how a “Still_On_ART_Code” (Integer) is converted into a string (text) format.

Figure: 5.3 Converting an integer data type into a string data type

```
DECLARE @ string Text

SET @ (Still_On_ART_Code, '1...3') ='Active'

Set @ (Still_On_ART_Code, '4' = 'Transferred_Out'

Set @ (Still_On_ART_Code, '5' = 'Decease'

Set@ (Still_On_ART_Code, '7') = 'Lost_To_Follow_up'

Set @ (Still_ON_ART_Code, '77') = 'Lost'

Select Convert (INT ‘StilL_On_ART_Code’, @stringVal),

From EPMS_Patient_Data;
```

This data transforming method can be replicated accordingly for all fields that need to be converted to a different data type. Furthermore, some data fields arrangement need to be specified. For example, all date fields need to have a common date arrangement in terms of date, month and year.

Step 5.4 Data Loading Approach for EPMS and EDT Systems

The data from EPMS or EDT system was loaded into the consolidated storage which is the interoperability model in the most convenient manner known as the batch data loading approach. The batch loading approach allowed the data loading to be scheduled and this happens periodically when it is convenient with the data needs. The researcher found the approach suitable because in HIV care, the most up-to-date data is not always readily available as it is dependent on the patient's visits and the workload at hand. Therefore, the data loading can be scheduled to happen when the data is up to date and when the connectivity is available.

5.5 EPMS and EDT Systems Canonical Data Model Components

a) Data sources

The data sources component includes both EPMS and EDT systems that are required to interoperate.

b) Global schema

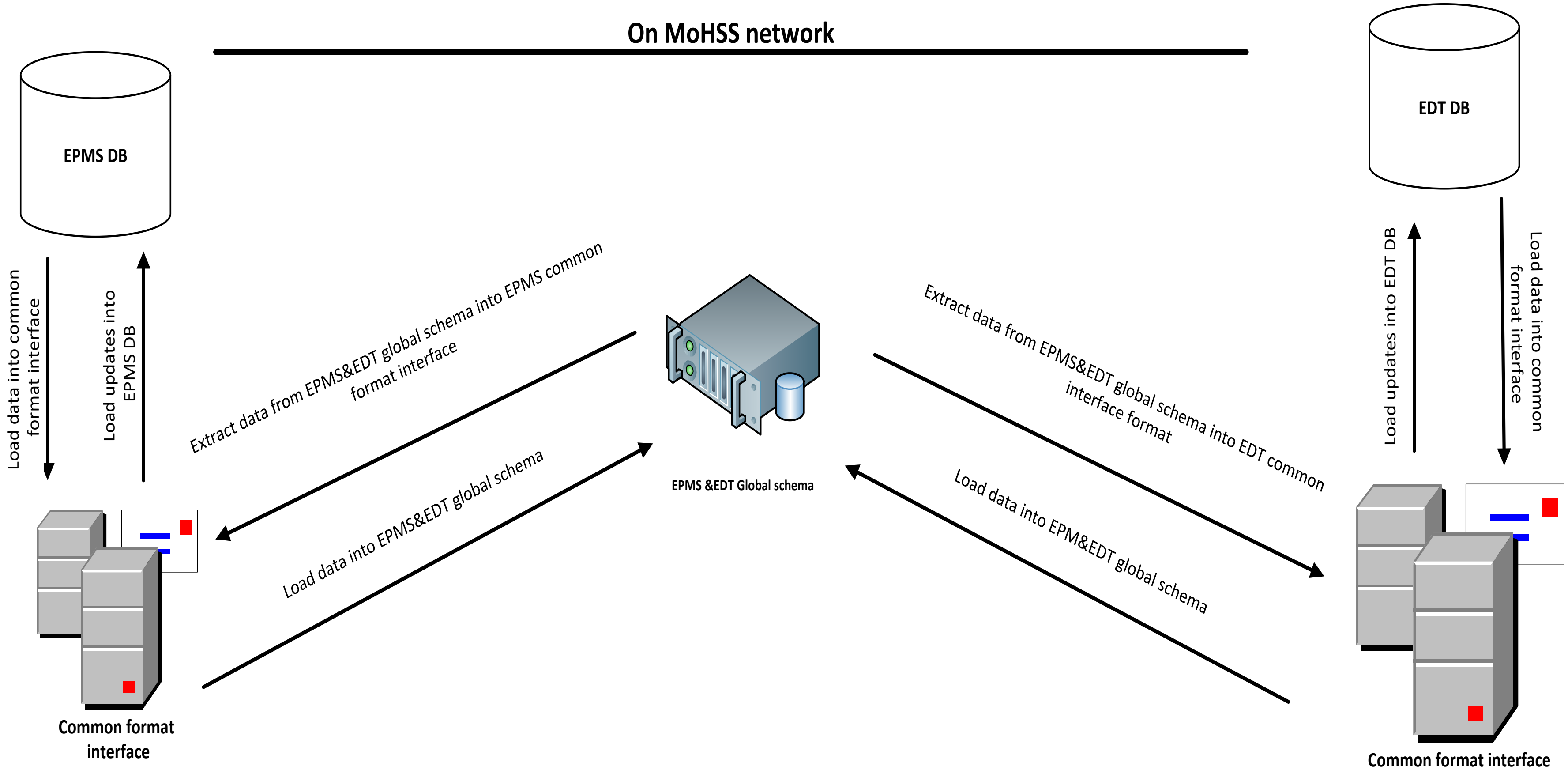
The global schema component will be the interoperability model. This interoperability model is in the form of a middleware which is developed from the common data fields of EPMS and EDT systems that are mapped together to create a single unified view. This addressed the syntactic and semantic heterogeneity of EPMS and EDT systems. The technology used in designing the canonical model is MS SQL. The table structure specified the data format that is required for all the common data fields. The data transformation happens before the data is exported to the global schema. The main patient record identifier used is the Unique ART number. This is because the findings revealed that the unique ART number is likely to be populated in both EPMS and EDT systems instead of the EDT number that is known as the pharmacy number. The data exchange between the EPMS, EDT and the canonical model is facilitated by Java scripts as an application programming interface (API).

c) Environment

The environment component consists of several elements that will influence the data exchange process between EPMS and EDT systems, namely:

- The technology available to support the data exchange process
- MoHSS ICT infrastructure in place

Figure 5.4.1: EPMS and EDT Systems' Canonical Model



The EPMS and EDT system canonical model diagram illustrates how EPMS and EDT systems will exchange data through a canonical data model architecture. Here the data is extracted from both EPMS and EDT systems into their common format interfaces respectively. Data extraction and loading processes will be scheduled to happen periodically when both systems are up to date, most likely by the end of each month so as to ensure that data exchange happens when new updates are available for each system and before reports are extracted from each system. The data is loaded into EPMS and EDT global schema by each system. Each system through its common interface format queries for updates which are loaded into the EPMS and EDT systems.

5.5 Steps followed to develop a canonical model

a) Problem analysis

   Problem analysis includes identifying a problem and the analysis of the problem. This includes formulating the problem objectives and scope.

b) Requirements identification and analysis

   This includes the process of collecting data through both the document analysis of EPMS and EDT systems and the interviews conducted with DSP, MoHSS' HIS department, and the pharmaceutical department to determine the needs and conditions that are required for the development of the EPMS and EDT systems interoperability model.

c) Generating ideas and concepts

   The research considered a process of reviewing and studying literature of related work covered by different researchers that are interested in solving similar problems. This includes the data integration process and frameworks and the design science research theory which was incorporated in the development of the EPMS and EDT interoperability model.

d) Environment

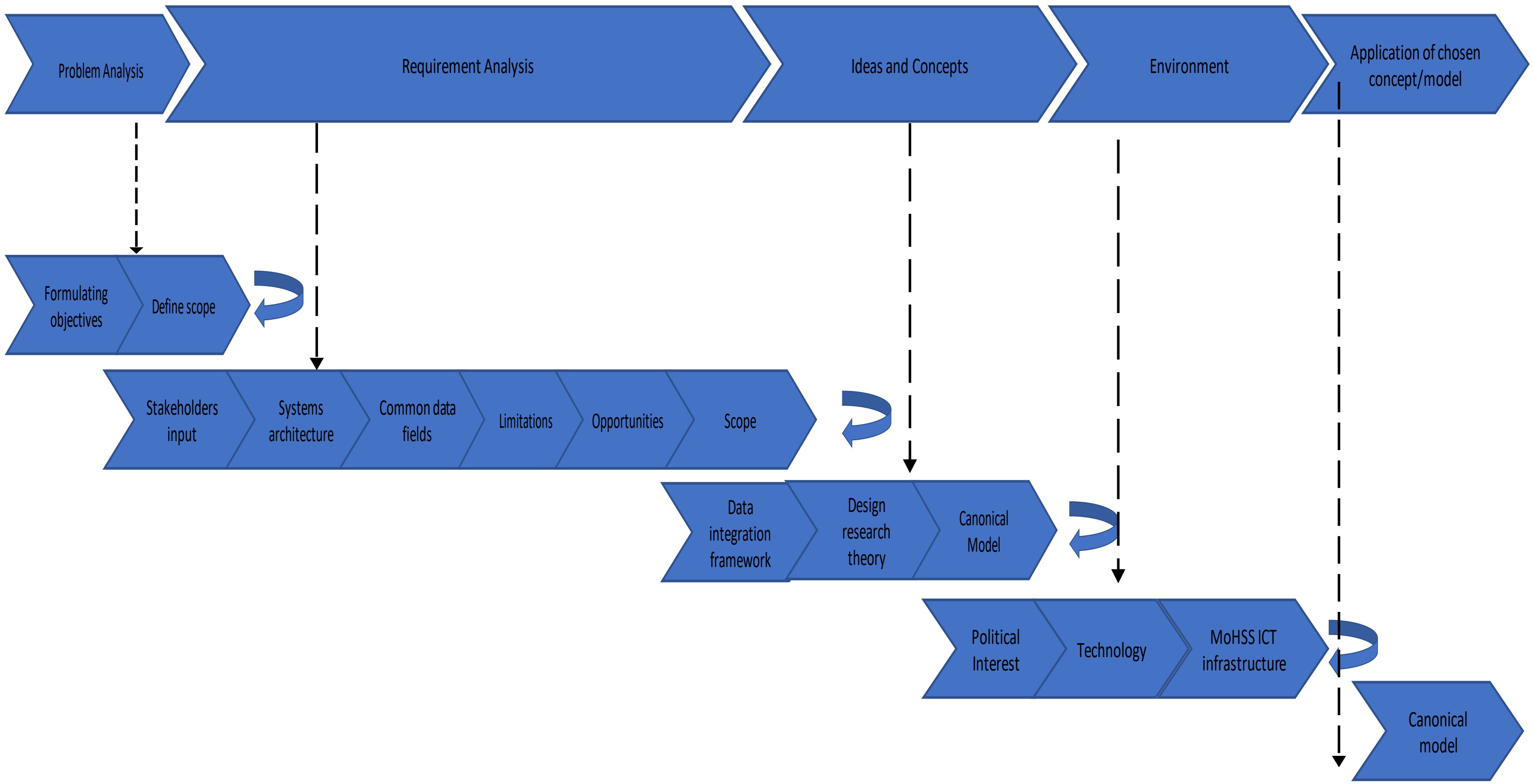
   The environment includes elements that can influence both the development of the EPMS and EDT systems' interoperability model and elements that are available to support the interoperability process. This includes the following:

- Political interest is crucial for the interoperability solution. This is because interoperability is not entirely technical but includes political buy-in that will make this process a reality, especially that the solution will benefit one of the most important public sectors, the ministry of health. Political interest will also ensure that all the required resources such as finances and human resources are available for the process to become a reality. This aspect further includes the EPMS and EDT systems' stakeholders to iron out the differences in terminologies and operations as identified by the research that contributes to reporting challenges by both EPMS and EDT systems. Moreover, the cabinet is also needed for it to finalise the drafted ICT governance policies that can enforce systems compatibility and interoperability for them to become operational.
- Technology includes the available technology that has been identified that is needed to support the interoperability of EPMS and EDT systems in their current states. This includes open database connection (ODBC) or Java database connectivity (JDBC) technology that support the platform of the EPMS system of which Filemaker and EDT system is SQL.
- MoHSS ICT infrastructure contributed to the development of the EPMS and EDT interoperability solution by providing guidance on providing the solutions that can be supported by the available ICT infrastructure

e) Application of a chosen concept/model

f) The research incorporated both literature and the data analysis findings to select the most fitting data model that can support EPMS and EDT system interoperability. The research chose a canonical data exchange model as the middleware to support data exchange for the EPMS and EDT system.

Figure 5.5.1 EPMS and EDT systems interoperability process



5.7 Chapter Conclusion

Seven guidelines of design science research theory were applied as a guide in the development of the EPMS and EDT systems interoperability model. Key findings from both content and thematic data analysis were incorporated in the design and development of the interoperability model. The research adopted a canonical data model as a middleware that enabled common data from both EPMS and EDT systems to be integrated in a unified manner. Lastly, the processes carried out during the design and development of the EPMS and EDT systems interoperability model are documented for future reference.

Chapter 6: Conclusion and Recommendations

6.1 Introduction

Health information systems interoperability is proven to be the key solution to an improved healthcare system and health-based decision making. The MoHSS in Namibia is supported by numerous health information systems that lack integration. This has resulted in data redundancy, discrepancies in monthly reports, and the lack of real-time data for decision making. Therefore, this research took an initiative to design and develop an interoperability model that will enable EPMS and EDT systems that administer HIV care data to interoperate in their current states.

6.1 Summary of the Research's Main Findings

The research objectives are the main drivers of the research findings. Therefore, in this section, the connections between the research objectives, research questions, and the research findings are discussed.

Research objective 1: To Examine Functional Data and Compatibility Issues of EPMS and EDT Systems

The research adopted a document analysis method to collect data on functional data and compatibility issues of EPMS and EDT systems from the user manuals and data dictionaries. The results indicated that the common data fields captured on both EPMS and EDT syshave different data types and formats. Furthermore, these common data fields are stored in completely different backend structures. Therefore, the research concluded that in terms of the syntactic and semantic, EPMS ad EDT systems are incompatible. This was addressed through the common data field mapping and data transformation process see figure 5.2 and 5.3.

Research Objective 2: To Analyse Reports Generated from EPMS and EDT Systems and Challenges involved in Producing a Common and Single Report

Document analysis of user manuals and data dictionaries for both systems and semi-structured interviews with DSP, pharmaceutical, M&E, and HIS departments of the MoHSS were methods that were used to collect data in this regard. The findings indicated that EPMS and EDT systems have only two similar reports that the MoHSS is interested in. These reports include the total number of patients started on ART treatment and the total number of active patients on ART over some time. The data collected further indicates that the indicator definitions of these two reports are not entirely the same and there were also some clinical operational discrepancies, hence the suggestion to have a common global schema load and extract data as demonstrated in the canonical model to address incompleteness of health records. Furthermore, the MoHSS stakeholders need to reach consensus on the indicator definition so as to focus on one output.

Research Objective 3: To Determine the Processes that are Required for the Integration of EPMS and EDT Systems

The research collected data using a document analysis method so as to identify HIV care processes that are supported by EPMS and EDT systems. The data fields collected through the identified processes were used in the data integration process of EPMS and EDT system. The data integration process forms part of the design and development of the canonical model that will enable EPMS and EDT systems to exchange data.

After the research objectives were set, it was defined what the research needed to do to meet its objectives. This was done by setting the research questions. In this section, the research revised the research questions and how the answers were provided to these questions.

The research's main question is: 'How can EPMS and EDT systems interoperate without compromising their current architectural designs?" The main research question was answered through the research's sub-questions.

Question 1: How can Functional Data and Compatibility Issues Be Resolved to Achieve EPMS and EDT Systems Interoperability?

This question was answered, whereby two sources contributed to the overall outcome of this question. Firstly, the literature on heterogeneous systems interoperability was the main contributor to answer this research question. The literature on heterogeneous systems interoperability reviewed by the researcher advocated for a unified schema to overcome functional data and compatibility issues. Similarly, during the semi-structured interviews, some participants indicated that EPMS and EDT systems interoperability can be achieved through a third party which requires data unification so as to overcome semantic and syntactic heterogeneity. A unified schema requires data mapping of common data fields as demonstrated on figure 5.2. .

Question 2: How Can EPMS and EDT Systems Produce a Common Report?

This question was answered. The researcher reviewed and analysed all common reports produced by EPMS and EDT systems so as to determine their similarities and differences through the document analysis process. These differences and similarities were further seconded by data collected through semi-structured interviews whereby the participants provided the reasons for the reports' discrepancies.

The data analysis process revealed that the discrepancies in EPMS and EDT common reports are caused by a combination of factors. Firstly, the results indicated that the indicator definitions of the common reports are slightly different. These are the differences in indicator definitions:

a) On EPMS, the report "Treatment new" includes patients that have been started on ART according to the Namibian MoHSS ART guideline. This means that on EPMS, patients that were started on ART from private hospitals or from outside Namibia are regarded as new on ART treatment, irrespective of their previous ART treatment history.
b) On a similar report known as "New patient started" on EDT, this report excludes patients that were started on ART medication from private hospitals or abroad.

As a result, the EPMS system is likely to report more patients that were started on ART than EDT. Therefore, a consensus on the indicator definitions needs to be reached by all MoHSS stakeholders for the reports to generate the same numbers.

Secondly, clinical operations have minor differences. The differences in clinical operations are as follows: During a follow-up visit on the EPMS system, a patient is required to be presented for all the data to be recorded. Furthermore, for the patient to be active on ART treatment in that facility, the patient does not need to miss their scheduled follow-up for more than 90 days. However, on EDT, a patient does not need to be present to collect medication, as they can send a treatment supporter to collect medication for them. Furthermore, EDT includes "in transit" patients in their total number of active patients that are not catered for on the EPMS system.

This means that the EDT system is likely to report more patients that are active on ART treatment than the EPMS system. This is emphasising the fact that if EPMS and EDT systems are to produce a common report on an active patient on ART treatment, the processes involved in data collection should be the same on both EPMS and EDT systems.

Question 3: What Processes Are Required to Integrate EPMS and EDT Systems?

This question was answered. The research provided answers to this question in the form of a model. Key findings from content and thematic data analysis were used in designing the interoperability model. The research provided step by step processes that were carried out to achieve EPMS and EDT interoperability goals. The processes carried out during the designing of EPMS and EDT systems interoperability model include:

a) Getting acquainted with the interoperability challenges faced by EPMS and EDT systems. This further includes setting the objectives as drivers of what needed to be achieved for EPMS and EDT systems to interoperate.
b) Knowledge-based consultation by the researcher in terms of both literature and data collected as input to the EPMS and EDT interoperability solution.
c) An environment that includes components that can influence EPMS and EDT systems interoperability such as political interest, available technologies, and the MoHSS's ICT infrastructure.
d) The suitable interoperability solution for EPMS and EDT system whereby an interoperability model was provided.

6.2 Recommendation Regarding Future Research on EPMS and EDT System's Interoperability

The research encourages future researchers to address any gap that was not discussed or addressed in this research. In Namibia, there is still room for research when it comes to ICT and IS in general, especially ICT and IS governance. The researcher would like to further encourage researchers to refine the interoperability model if needed. This interoperability model forms part of the knowledge base and guideline on how EPMS and EDT systems can interoperate. Therefore, the researcher would welcome fellow researchers to learn from this research and use it to develop a prototype of the EPMS and EDT system interoperability model.

The interoperability model for EPMS and EDT can be a real solution to all challenges associated with the lack of systems interoperability that is being experienced by the DSP. Therefore, the MoHSS should evaluate the utility of this research as a future solution to EPMS and EDT interoperability.

6.3 Chapter Conclusion

Technically, this research emphasises that EPMS and EDT can interoperate through a model due to the level of heterogeneity of EPMSS and EDT systems. A data model that enables EPMS and EDT systems to interoperate in their current designs is the solution provided by this research. Therefore, the steps and processes provided can be used in developing a prototype of the model that can support EPMS and EDT systems to exchange data.

Appendices

Appendix A: Data Collection approval letter MoHSS.

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OFFICE OF THE EXECUTIVE DIRECTOR

Ref: 17/3/3 PNK
Enquiries: Mr. A. Shipanga

Date: 17 December 2019

Ms. Puyeipawa N. Kandume
PO Box 41544
Auspannplatz
Windhoek

Dear Ms. Kandume

***Re:* Application for data exchange between EPMS and EDT systems in the Directorate of special programs of the Ministry of Health and Social Services (MoHSS).**

1. Reference is made to your application to conduct the above-mentioned study.

2. The proposal has been evaluated and found to have merit.

3. **Kindly be informed that permission to conduct the study has been granted under the following conditions:**

3.1 The data to be collected must only be used for academic purpose;

3.2 No other data should be collected other than the data stated in the proposal;

3.3 Stipulated ethical considerations in the protocol related to the protection of Human Subjects should be observed and adhered to, any violation thereof will lead to termination of the study at any stage;

3.4 A quarterly report to be submitted to the Ministry's Research Unit;

3.5 Preliminary findings to be submitted upon completion of the study;

3.6 Final report to be submitted upon completion of the study;

3.7 Separate permission should be sought from the Ministry for the publication of the findings.

4. All the cost implications that will result from this study will be the responsibility of the applicant and **not** of the MoHSS.

Yours sincerely,

BEN NANGOMBE
EXECUTIVE DIRECTOR

Appendix B: Data Collection Tools

NAMIBIA UNIVERSITY
OF SCIENCE AND TECHNOLOGY

FACULTY OF COMPUTINGAND INFORATICS

Research Topic:

APPLICATION FOR DATA EXCHANGE BETWEEN EPMS AND EDT SYSTEMS IN THE DIRECTORATE OF SPECIAL PROGRAMS OF THE MINISTRY OF HEALTH AND SOCIAL SERVICES [MOHSS]

DEPARTMENT OF INFORMAICS

Request to conduct Semi-structured interview in fulfilment for the degree of

Master of Informatics

At the

NAMIBIA UNIVERSITY OF SCIENCE AND TECHNOLOGY

Presented by: Puyeipawa N. Kandume

Supervisor: Dr. Suama Hamunyela

1

Instructions:
Ethical conduct, voluntary participation, confidentiality, withdrawing

Key: I = Interviewer
R = Respondent
EPMS = electronic Patients Management System
EDT = Electronic Dispensing Tool

Place: Directorate of Special Programs (DSP)

Interviewer: Puyeipawa Kandume

Transcriber: Puyeipawa Kandume

Participants required for the interview:

- 2 EPMS/EDT Systems Analysts
- 4 M&E officers and 2 data managers for ART data
- 2 MoHSS IT administrators

Date:
Start time: End time:

I: Do you agree to participate freely and to give honest answers to the interview questions?

R: Yes ☐ No ☐

(Question 1)

I: Do you think it's important for the Electronic Patient Management System (EPMS) and Electronic Dispensing Tool (EDT) systems to exchange data?

R: ____

____

(Question 2)

I: How can data exchange between Electronic Patient Management System (EPMS) and Electronic Dispensing Tool (EDT) systems can be achieved?

R: ____

____

____

2

(Question 3)

I: Do you think there is a need for the Electronic Patient Management System (EPMS) and Electronic Dispensing Tool (EDT) to generate a common report? Will it be useful to you?

R:____

(Question 4)

I: What are the challenges involved in generating a common report from Electronic Patient Management System (EPMS) and Electronic Dispensing Tool (EDT) systems?

R:____

(Question 5)

I: Do you think it's possible for Electronic Patient Management System (EPMS) and Electronic Dispensing Tool (EDT) systems to share data in their current architectural designs?

R:____

(Question 6)

I: Do you think the current infrastructure can support the Electronic Patient Management System (EPMS) and Electronic Dispensing Tool (EDT) data exchange? In what way?

R:____

(Question 7)

I: Does the MoHSS coordinate the requisitioning or development of software/ hardware?

3

R:____

____

____

(Question 8)

I: Does the MoHSS have plans to integrate Electronic Patient Management System (EPMS) and Electronic Dispensing Tool (EDT) systems?

R:____

____

____

Thank you very much for your time and participation.

End

4

Appendix C: Coding of Interview Transcripts

Interview extract	Colour	Codes
Interview 1 ○ Absolutely, of course, [*clearing throat*], definitely ○ triangulation of patient data, that we want to validate, we have to have the correct number of active patients basically. Data validation ○ EDT, we have limitations basically, and I'm pretty sure EPMS also have some limitations, ○ it's either we reengineer the technology in the old system or we update it to a new software, for the two systems to be speaking to each other ○ require significant monetary resources for us to reengineer, ○ that's a huge gap, huge variation, ○ they don't have WIFI access or something like that? it will be very difficult, and the EDT is not web based yet. So, it will be very difficult. ○ is the unique number that the systems shares ○ they have to actually control the number of information systems collecting and storing data for the ministry	○ Yellow ○ Turquoise ○ Violet ○ Grey ○ Pink ○ Bright green ○ Blue ○ Dark grey ○ Dark yellow	○ Certainty /agreement ○ Common report ○ Limitations ○ Proposed solution ○ Lack of funds ○ Distrust of report ○ Infrastructure ○ Common data ○ E-governance
Interview 2 ○ it should actually go hand in hand	○ Yellow ○ Dark grey	○ Certainty/Agreement ○ Common data

○ Yes, because in most of the time, it will actually prevent of patients for miss entering of patients' personal details, demographic details, so if the systems are connected, you can only enter in one system and just share the information. ○ The best way is if the systems are running on one platform, So, if we can be able to find a third party, even a software, can happen if we are having both systems which are actually running on the same infrastructure and on the same network. ○ EPMS has the highest number of active compare to the pharmacy ○ people don't know which one to trust ○ They can only run on standalone. they are not on the same network and they are not in the same room. ○ The building it can be in the same building. But the EDT system does not also, it's not connected on the ministry's network ○ It's mostly because of the indicators. Each system measures different indicator, so that makes it difficult to measure or collect different indicators., ○ The problem lies with the different NGOs that are handling the systems, most of the programs are donor driven. ○ Each donor does not want to give up their system. ○ The one with EPMS, wants to keep EPMS and the one with EDT wants to keep EDT ○ The ministry does not have funds to get in new systems that's why they depend on the donor. ○ the ministry have a standard	○ Light grey ○ Bright green ○ Blue ○ Bark red ○ Red ○ Pink ○ Dark yellow	○ Proposed solution ○ Distrust of reports ○ Infrastructure ○ Distinct operations ○ Market niche ○ E-governance

Interview 3 ○ Yes, I think it's very important for the two systems to exchange data as they are all dealing with patient management. ○ we are trying to come up with a simplified version of EDT which will in the future maybe will collaborate with the EPMS, whereby they can fill each other with information. ○ we are in that processes already of trying to do the data triangulation ○ EDT is just a desktop application, offline application ○ one is on sql and the other one is on filemaker.	○ Yellow ○ Grey ○ Turquoise ○ Blue ○ Green	○ Certainty ○ Proposed solution ○ Common report ○ Infrastructure ○ Platforms
Interview 4 ○ MoHSS HIS department relies on the ICT standards maintained by the OPM. ○ They currently have COBIT and ITILL. ○ They had also drafted the IT security policy which is yet to be reviewed by the cabinet	○ Dark yellow	○ E-governance
Interview 5	○ Yellow	○ Certainty

○ it is very important for EPMS and EDT systems to exchange data. ○ we always compare new patients on ART and Active patients on ART from the EDT system. So, I think it's important for the systems to generate the same reports. ○ EDT has in-transit patients that are not captured in EPMS, We also have patients that sent their treatment supporter to collect their ARV medication for them. ○ Not all the facilities have internet.	○ Turquoise ○ Dark red ○ Blue	○ Common report ○ Distinct operations ○ Infrastructure

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